TECHNICAL MANUAL

INSTRUCTIONS WITH PARTS LIST

PRECISION AUTOMATIC NOISE FIGURE INDICATOR

TYPE 75

(AIRBORNE INSTRUMENTS LABORATORY)

AF33(657)13403

F41608-81-D-A062

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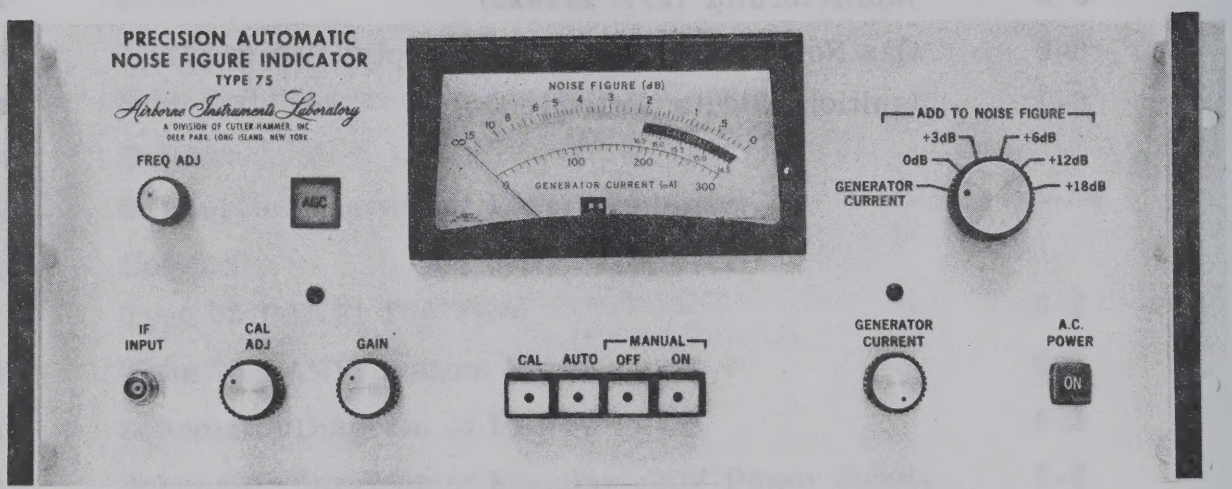


FIGURE 1-1. PRECISION AUTOMATIC NOISE FIGURE INDICATOR

SECTION I

INTRODUCTION

This is a vendor commercial manual revised to meet Government commercial manual requirements. Contained herein are operating and maintenance instructions with parts list for Type 75 Precision Automatic Noise Figure Indicator (commonly referred to throughout this manual as PANFI), manufactured by Airborne Instruments Laboratory (AIL), Deer Park, Long Island, New York.

NOTE

Recommendations proposing changes to this manual shall be submitted on AFTO Form 22 in accordance with T.O. 00-5-1 to the following addressee:

AFPRO GD/CAD (QAE) ATTN: CTOCU
P.O. Box 371
Fort Worth, Texas 76101

The AIL Type 75 Precision Automatic Noise Figure Indicator (PANFI), when used with an appropriate AIL Type 70 Noise Generator, provides a continuous and direct meter reading in dB of the noise figure of a device under test. AIL Type 70 Noise Generators, covering a 10 MHz to 40 GHz range are available for use with the AIL Type 75 Precision PANFI for automatic or manual noise figure measurement.

The continuous, accurate, indication of the noise figure of the device under test permits adjustment of the circuit parameters for minimum noise figure. The device under test may be a complete receiver (radar, telemetry, etc.), an amplifier (traveling-wave-tube type, reactance type, etc.), an IF amplifier, or a mixer-IF amplifier combination. The operational simplicity and extreme accuracy of indication makes the PANFI suitable for use in both laboratory and production facilities.

Manual (Y-factor) measurements with an accuracy of ±0.25 dB may be made by using the calibrated output indicator of the AIL Type 75 PANFI. When greater accuracy is required, the PANFI can be used in conjunction with the AIL Type 32 Precision IF Attenuator.

SECTION II

SPECIFICATIONS

Noise figure ranges	0 to 33 dB in 5 ranges; scale to infinity on all ranges	
Full scale ranges	0, 3, 6, 12, and 18 dB	
Accuracy* (automatic mode)	0-dB range	0 to 3 ±0.15 dB 3 to 6 ±0.25 dB
	3-dB range	3 to 6 ±0.15 dB 6 to 9 ±0.25 dB
	6-dB range	6 to 9 ±0.15 dB 9 to 12 ±0.25 dB
	12-dB range	12 to 18 ±0.5 dB
	18-dB range	------- ±1.0 dB
AGC	65 dB	
Input sensitivity	50 μV (normal 30-MHz operation) 100 μV (using converter, AIL P/N 07530)	
Input frequency	30 MHz with a 5-MHz BW or 40 to 150 MHz continuously tunable with a 4-MHz BW (using converter AIL P/N 07530)	
Operating modes	Automatic, Manual, and Calibrate	
Input impedance	50 ohms (nominal)	
Gas noise generator power supply	Modular unit: may be removed for remote operation of gas-discharge noise generator (up to 1000 feet)	
	Output current: 100 - 250 mA (adjustable from front panel)	
	Ionization pulse: 5 kV (typical)	

* As compared to manual measurement (excluding noise source) using AIL Type 32 Precision Attenuator.

Diode gate output	Synchronized trigger signal to permit operation of AIL Type 70 Diode Noise Source P/N 07001
Recorder output	50 mV dc (at full scale meter deflection); 5-kilohm output impedance, ungrounded
Operating temperature	0 to 50°C
Power required	115/230 V ac ±10%, 50 to 400 Hz 1 A/0.5 A
Weight	38 pounds
Size (Figure 2-1)	19-inches wide 20-1/8 inches deep 7-inches high

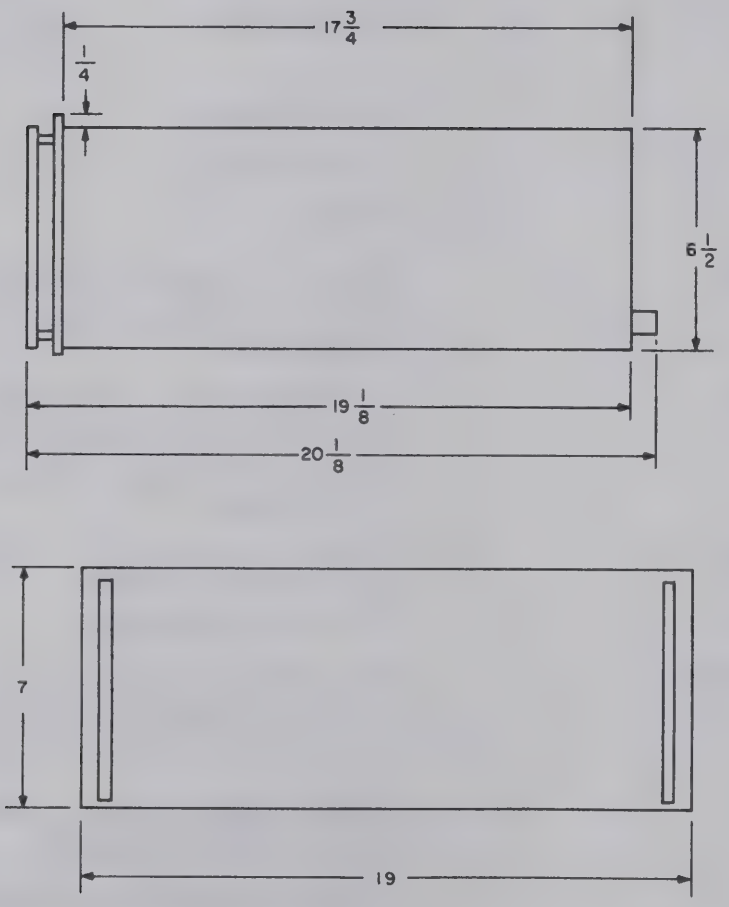
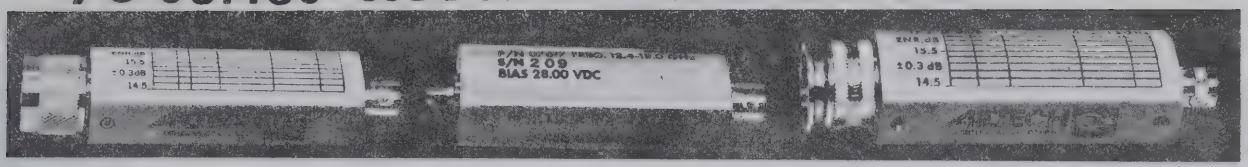


FIGURE 2-1. OUTLINE DRAWING

76 series SOLID STATE NOISE GENERATORS



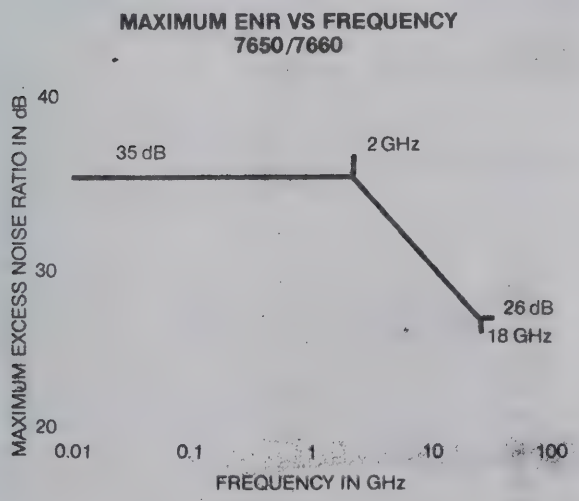
AILTECH 7615, 7616, 7617:

The most important characteristic of a noise generator is the accuracy with which its excess noise ratio (ENR) is known. Every generator in this series is calibrated against a known noise standard (traceable to the National Bureau of Standards, where applicable) using the highly-regarded AILTECH 82 Microwave Noise Temperature Calibration System. The calibration frequencies and excess noise ratio accuracy are shown in the specs below. As an option, these generators can be calibrated at other frequencies in their respective ranges with improved accuracies. (Request Application Bulletin 70-32 for further details on calibration service.)

SPECIFICATIONS

Part Number	07615	07616	07617
Frequency Range (GHz)	0.01-1.5	1-12.4	12.4-18
Excess Noise Ratio (dB)	15.5 ± 0.5	15.5 ± 0.5	15.5 ± 1
Calibration Freq. (GHz)	0.03, 0.3, 1.0, 1.5	1, 2, 3.95, 8.2, 12.4	12.4, 15, 18
ENR Accuracy* (dB)	±0.3	±0.3	±0.25
Temperature Sensitivity	0.01dB/°C	0.01dB/°C	0.01dB/°C
Voltage Sensitivity	0.1 dB/%	0.1 dB/%	0.1 dB/%
VSWR (maximum)	1.2	1.2	1.3
Output Connector	N male	N male	OSM female
Input Connector	BNC female	BNC female	BNC female
Input Requirements	28 volts at less than 30 ma.	28 volts at less than 30 ma.	28 volts at less than 30 ma.
Weight	3 oz. (85 gr.)	3 oz. (85 gr.)	3 oz. (85 gr.)

*Accuracy of the ENR data at the calibration frequencies. Data, supplied at no additional charge, is provided on a data sheet accompanying each unit and is also plotted on a graph on the noise generator body.



AILTECH 7650, 7660

(The difference between these two units is in the type of output connector—7650 has a type N-Male while 7660 has a 3mm—female.)

The convenience of solid-state, low-power requirements, small size and weight, plus the high-level output makes the AILTECH noise sources ideal for system noise monitoring applications. A high excess noise ratio permits the user to inject noise into a receiver system through a coupler and still attain a reasonably high, injected noise power in the system for measurement of noise figure or operating noise temperature. Use of high-value couplers reduces noise degradation of the receiver when the monitoring function is not active. Small size and the need for only a single coaxial power connection make antenna feed mounting particularly convenient.

Operating up to 18 GHz with typically a 15-percent bandwidth, these devices can be provided with excess noise ratios of as high as 37 dB.

AILTECH's experience in the manufacture, characterization, and calibration of noise measurement equipment permits specification of the ENR of a typical device to within ±0.5 dB. Isolators or couplers can be supplied at additional cost (or supplied by the customer), and the calibration can be performed at the output port thus eliminating another source of system error.

All units operate from +28 volts DC at less than 30 mA. This greatly simplifies operating the units at remote locations.

SPECIFICATIONS

Part Number	7650-X[1]	7660-X[1]
Frequency Range	10 MHz to 18 GHz	10 MHz to 18 GHz
Bandwidth[2]	Up to 15 percent	Up to 15 percent
Maximum Excess Noise Ratio[2]	See graph	See graph
Typical VSWR[3]	4:1	4:1
Output Connector	Type N-male	3 mm-female
Input Connector	BNC-female	BNC-female
Power Required	28.0 V at 30 mA maximum	28.0 V at 30 mA maximum
Overall Dimensions (nominal)	1 x 1 x 4 in. (2.54 x 2.54 x 10.2 cm)	1/2 x 1/2 x 2-1/2 in. (1.27 x 1.27 x 6.4 cm)
Weight	3.5 oz (99 g)	2.7 oz (76.5 g)

Notes:
[1] Last digit assigned to each specific noise source
[2] Higher ENR and wider bandwidths available at additional cost
[3] RF isolators can be supplied at additional cost

AILTECH

East Coast Operation • 2070 Fifth Avenue • Ronkonkoma, N.Y. 11779
Telephone: (516) 588-3600 • TWX: 510-228-6507
City of Industry Operation • 19535 East Walnut Drive • City of Industry, CA 91748
Telephone: (213) 965-4911 • TWX: 910-584-1811
Los Angeles Operation • 5340 Alla Road • Los Angeles, CA 90066
Telephone: (213) 822-3061 • TWX: 910-343-6969
France • La Garenne-Colombes • Telephone (01) 7807373 • Telex 620821
United Kingdom • Crowthorne • Telephone 5777 • Telex 851-847238
Germany • Munich • Telephone (089) 5233023 • Telex 841-529420
Holland • Amsterdam • Telephone 31-2977-29376 • Telex 844-18399

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SECTION III

OPERATING CONTROLS, INDICATORS, AND CONNECTORS

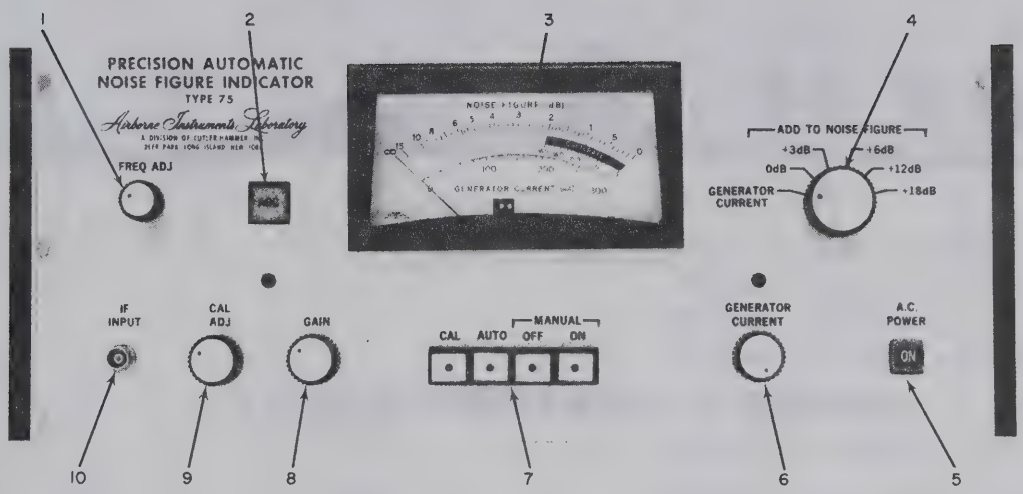


FIGURE 3-1. FRONT PANEL CONTROLS

Index No. (Figure 3-1, 3-2)	Description	Function
1	FREQ ADJ Control	Adjusts frequency of tunable input (optional).
2	AGC indicator	Indicates that input signal is above minimum level required for AUTO or CAL mode of operation.
3	Meter	Indicates noise figure, excess noise ratio, or gas-discharge noise generator current.
4	Scale selector	Selects desired noise figure scale or noise generator current scale.

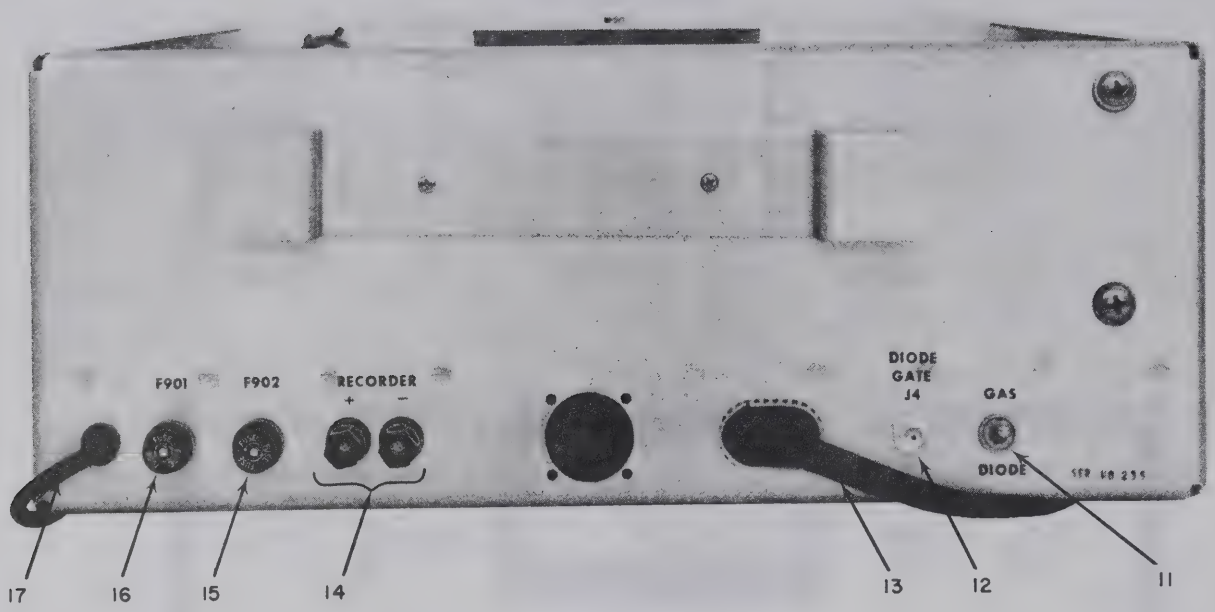


FIGURE 3-2. REAR PANEL CONTROLS

Index No. (Figure 3-1, 3-2)	Description	Function
5	AC POWER switch	Controls application of ac primary power.
6	GENERATOR CURRENT control	Adjusts gas-discharge noise generator current.
7	Selector switches	Select operating condition as indicated.
7a	CAL	Sets meter to read calibration of instrument to known excess noise ratio of external noise generator.
7b	AUTO	Sets meter to read automatic noise figure.
7c	MANUAL OFF	Converts instrument to total power receiver and turns noise generator off.

Index No. (Figure 3-1, 3-2)	Description	Function
7d	MANUAL ON	Converts instrument to total power receiver and turns noise generator on continuously.
8	GAIN control	Adjusts IF postamplifier gain during manual operation.
9	CAL ADJ control	Calibrates instrument to known excess noise ratio of external noise generator indicated on CALIBRATE meter scale.
10	IF INPUT connector	Input connector from device under test.
11	GAS-DIODE switch	Selects gas-discharge or diode noise generator being used; removes ignition pulse from anode connector when not in use.
12	DIODE GATE connector	Provides access to gate signal output for diode noise generator.
13	Cables	Anode and cathode cables for connection to AIL Type 70 Gas-Discharge Noise Generators.
14	RECORDER connectors	Output connectors for external recorder.
15	FUSE	Provides overload protection.
16	FUSE	Provides overload protection.
17	AC Line Cord	Provides connection for input ac power from line source.

SECTION IV

OPERATING INSTRUCTIONS

4.1 AUTOMATIC NOISE FIGURE MEASUREMENT USING GAS-DISCHARGE NOISE GENERATOR

To make an automatic noise figure measurement, using the gas-discharge noise generator, proceed as follows:

1. Connect the equipment as shown in Figure 4-1.

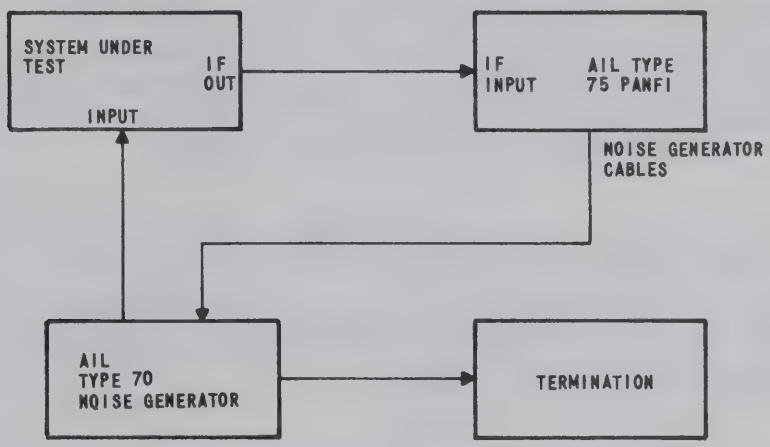


FIGURE 4-1. AUTOMATIC NOISE FIGURE MEASUREMENT USING GAS-DISCHARGE NOISE GENERATOR

2. Set GAS-DIODE switch to GAS position.
3. Set GENERATOR CURRENT control fully counter-clockwise.
4. Depress MANUAL OFF button.
5. Set scale selector to GENERATOR CURRENT.
6. Depress AC POWER button.

7. Depress MANUAL ON button and adjust GENERATOR CURRENT control for the meter current setting recommended in Table 4-1.

8. Depress CAL button and rotate the scale selector switch to any position except GENERATOR CURRENT; note that the AGC front panel indicator is illuminated. This indicates that the input signal is above the minimum required level. (If it is not, the gain of the device under test may be too low.)

9. While observing the CALIBRATE scale (green band) of the front panel meter, rotate the CAL ADJ control to obtain the appropriate excess noise ratio for the noise generator being used (Table 4-1).

10. After depressing the AUTO button, rotate the scale selector switch to obtain a convenient reading on the NOISE FIGURE scale of the front panel meter.

CAUTION

The AGC indicator must be on for all automatic noise figure readings; if it is not on, the gain of the device may be too low.

11. Read the noise figure (in dB) of the system under test, on the meter.

4.2 AUTOMATIC NOISE FIGURE MEASURING USING DIODE NOISE GENERATOR

To make an automatic noise figure measurement using a diode noise generator, proceed as follows:

1. Connect equipment as shown in Figure 4-2.

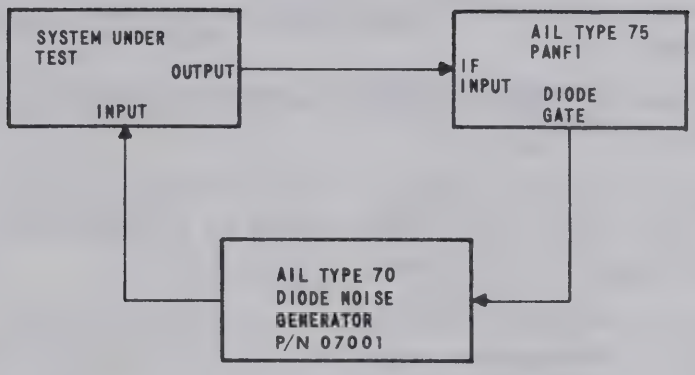


FIGURE 4-2. AUTOMATIC NOISE FIGURE MEASUREMENT USING DIODE NOISE GENERATOR

TABLE 4-1. METER CURRENT SETTINGS

Generator	Excess Noise Ratio (dB)	Tube Current (mA)
07010	15.65	175
07011	15.65	175
07012	15.75	175
07048	15.35	175
07049	15.60	175
07050	15.65	175
07051	15.75	175
07052	15.75	175
07053	16.15	150
07091	16.15	150
07096	16.30	100

2. Set the GAS-DIODE switch to the DIODE position.
3. Depress MANUAL OFF button.
4. Set scale selector to any convenient noise figure position.
5. Depress AC POWER button and the MANUAL ON button.
6. Depress the CAL button. The AGC light must be on. If it is not, the input signal to the PANFI is below the minimum level required.
7. Use the CAL ADJ control to set the front panel meter to the excess noise ratio (on the CALIBRATE scale, in dB) of the diode noise source. The scale selector may be in any position except NOISE GENERATOR. The system is now calibrated.
8. Depress the AUTO mode button and set the scale selector for an on-scale meter reading.

CAUTION

The AGC indicator light must be on for all automatic noise figure readings.

9. Read the noise figure (in dB) of the device under test, on the meter.

4.3 MANUAL NOISE FIGURE MEASUREMENT (Y-FACTOR) USING GAS-DISCHARGE NOISE GENERATOR

To make the manual noise figure measurement (Y-factor) using a gas-discharge noise generator, proceed as follows:

1. Connect the equipment as shown in Figure 4-3.

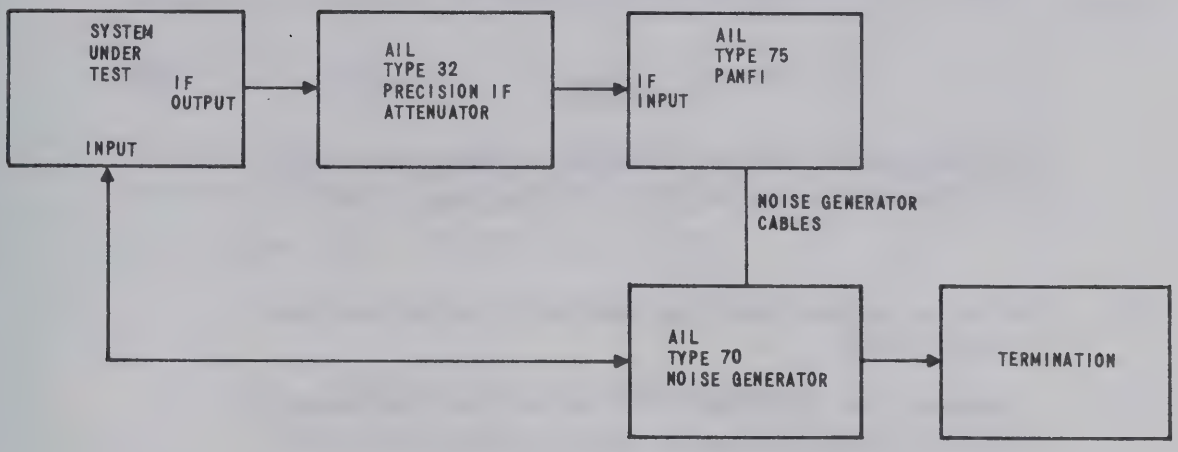


FIGURE 4-3. MANUAL NOISE FIGURE MEASUREMENT USING GAS-DISCHARGE NOISE GENERATOR

2. Set the GAS-DIODE switch to the GAS position.
3. Set the GENERATOR CURRENT control fully counterclockwise.
4. Depress the MANUAL OFF button.
5. Set the scale selector to GENERATOR CURRENT position.
6. Depress the AC POWER button.
7. Depress the MANUAL ON button and adjust the GENERATOR CURRENT control for the meter current setting recommended in Table 4-1.
8. Depress the MANUAL OFF button. The scale selector switch may be set to any position without affecting the accuracy of the manual measurement.

9. Adjust the GAIN control and the precision attenuator for a convenient meter reading.

NOTE

All attenuator settings should be obtained using counterclockwise rotation to eliminate backlash.

10. Note the meter reading and the precision attenuator setting.

11. Depress the MANUAL ON button and increase the precision attenuator setting until the meter returns to the setting noted in step 10.

NOTE

Do not disturb the GAIN control setting.

12. Subtract the attenuator reading in step 10 from that in step 11. This is the Y-factor (in dB).

13. To check for possible reading errors, depress the MANUAL OFF button and readjust the precision attenuator to obtain the meter reading noted in step 10. Note that the attenuator reads the same as in step 10.

The noise figure of the device under test can be computed from:

$$F = \frac{\frac{T_2}{T_o} - 1}{Y - 1} \qquad (4\text{-}1)$$

where

T_2 = effective temperature of the noise generator in the ON condition.

T_o = 290° Kelvin (standard reference temperature).

Y = ratio of the noise output of the device under test with the noise generator ON to that with the noise generator OFF.

The noise figure (in dB) is given by:

$$F_{dB} = 10 \log\left(\frac{T_2}{T_o} - 1\right) - 10 \log (Y - 1)$$

where $10 \log\left(\frac{T_2}{T_o} - 1\right)$ is the excess noise ratio (T_{ex}) of the noise generator (in dB).

In lieu of actual computation, the noise figure can be computed from either the AIL noise figure slide rule, or from Figure 4-4.

4-4. MANUAL NOISE FIGURE MEASUREMENT USING DIODE NOISE SOURCE P/N 07001

To make a noise figure measurement (Y-factor) using the Type 70 Diode Noise Source, proceed as follows:

1. Set up the equipment as shown in Figure 4-5.
2. Set the GAS-DIODE switch to the DIODE position.
3. Depress the MANUAL OFF button.
4. Set the scale selector to the 0-dB position.
5. Depress the AC POWER button.
6. Adjust the GAIN control and the precision attenuator for a convenient reference reading on the PANFI meter.
7. Note the attenuator reading.
8. Depress the MANUAL ON button.

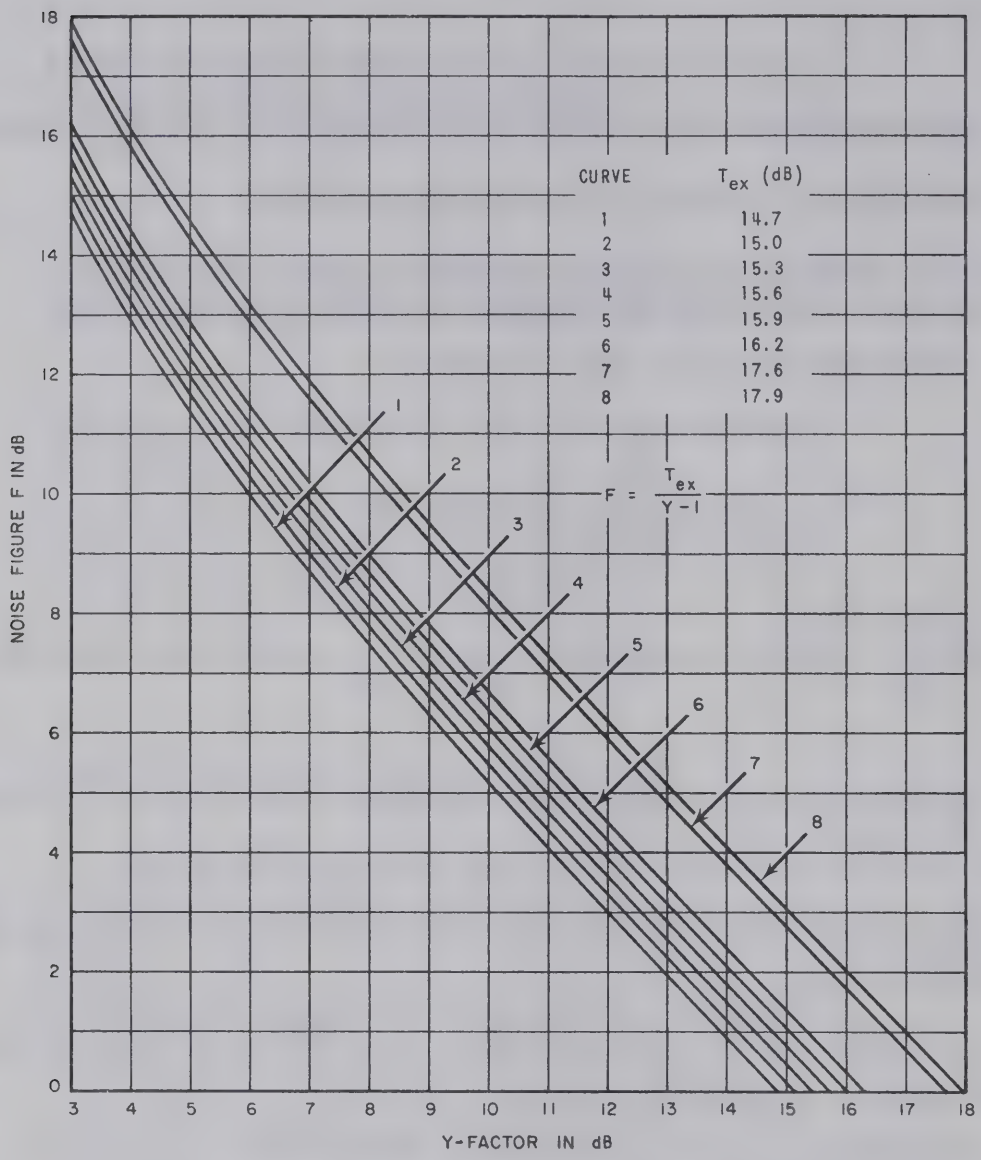


FIGURE 4-4. Y-FACTOR VERSUS NOISE FIGURE

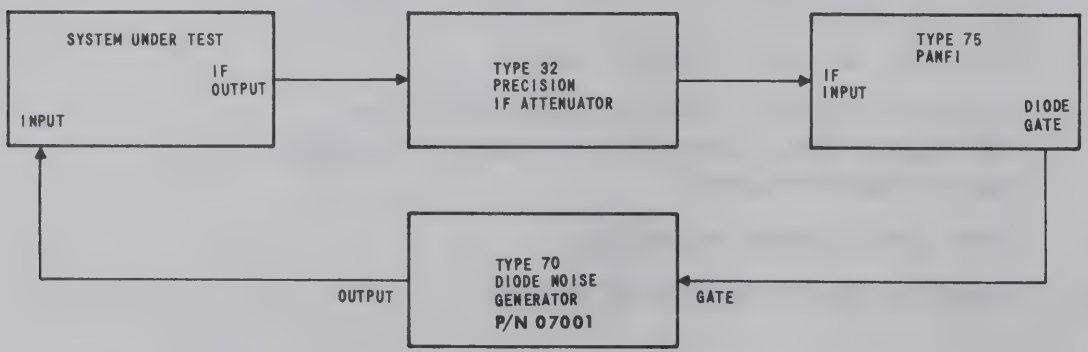


FIGURE 4-5. MANUAL NOISE FIGURE MEASUREMENT USING TYPE 70 DIODE NOISE GENERATOR P/N 07001

9. Increase the precision attenuator setting until the PANFI meter returns to the reference noted in step 6. Note this attenuator reading.

10. Subtract the attenuator reading in step 7 from that in step 9; this is the Y-factor (in dB).

To check for possible reading errors, depress the MANUAL OFF button and readjust the attenuator to obtain the same reading noted in step 6 on the PANFI meter. The noise figure of the device under test can be computed by the methods described in paragraph 4.3.

4.5 MANUAL Y-FACTOR MEASUREMENTS USING THE AIL TYPE 75 CALIBRATED OUTPUT INDICATOR

When a manual Y-factor measurement is desired and an AIL Type 32 Precision Attenuator is not available, the calibrated output indicator of the Type 75 PANFI may be used The accuracy of the measurement will be within 0.4 dB. To make the measurement perform the procedures listed in the following steps.

1. Set up the equipment as shown in either Figure 4-1 or 4-2 as applicable.

2. Depress the MANUAL OFF button.

3. Set the GAS-DIODE switch to either DIODE or GAS depending upon which type of noise source is being used.

4. Set the scale selector to the 0-dB position.

5. Depress the AC POWER button.

6. If the AIL Type 70 Diode Noise Source is being used, depress the MANUAL ON button.

7. If the AIL Type 70 Gas-Discharge Noise Generator is being used, depress the MANUAL ON button and set the scale selector to GENERATOR CURRENT position. Adjust the GENERATOR CURRENT control for the meter current shown in Table 4-1.

8. Set the scale selector to the 0-dB position and adjust the GAIN control for full scale meter reading (0 dB).

9. Depress the MANUAL OFF button and change the scale selector for a convenient meter reading.

10. Add the scale selector reading to the meter reading (in dB) to obtain the Y-factor.

The noise figure of the device under test can be computed using the method discussed in paragraph 4-3.

4.6 USE OF THE CONVERTER PART NO. 07530 WITH THE TYPE 75 PRECISION ANFI

The Converter, Part Number 07530, is available as an accessory to the AIL Type 75 PANFI. When this converter is used, the Type 75 PANFI can be used to test systems with output frequencies other than 30 MHz (see specifications).

To set the converter at the desired operating frequency, proceed as follows:

1. Connect a signal generator to the front panel IF INPUT jack on the PANFI.
2. Depress the MANUAL OFF button.
3. Set scale selector to 0-dB range.
4. Depress AC POWER button.
5. Set the signal generator to the desired frequency of operation (between 40 and 150 MHz) and adjust its output to approximately -40 dBm.
6. Set the GAIN control to approximately mid-position.
7. Adjust FREQ ADJ control for a maximum reading on the front panel meter. If necessary, increase or decrease the GAIN control for an on-scale reading.
8. The Type 75 Precision ANFI is now ready for measurement at the desired frequency.

4.7 thru 4.7.2 (Deleted)

FIGURE 4-6 DELETED

 Pages 4-11 thru 4-12 deleted

4.8 ACCURACY CONSIDERATIONS

4.8.1 NOISE GENERATOR ERROR

Noise figure measurements assume an accurate knowledge of T_{ex}, the excess noise ratio of the noise source being used. In the case of gas-discharge noise generators, this value is a function of various physical characteristics.

In general, the noise power output is not constant over the entire operating frequency range or the same for all noise generators. Refer to Table 4-1 to determine the T_{ex} for the noise generator being used. This value is then set on the meter when calibrating the PANFI, thus automatically adjusting the meter to read the correct noise figure for the particular noise generator.

The excess noise ratio of a gas-discharge noise generator is a function of the coupling of the microwave structure to the discharge. This is related to the fired and unfired insertion loss of the gas-discharge noise generator. Figure 4-7 shows the effect of insertion losses on the excess noise ratio of the noise generator. The production tolerance of the lamps is ± 0.25 dB, with an uncertainty on the center value of ± 0.2 dB. Therefore,

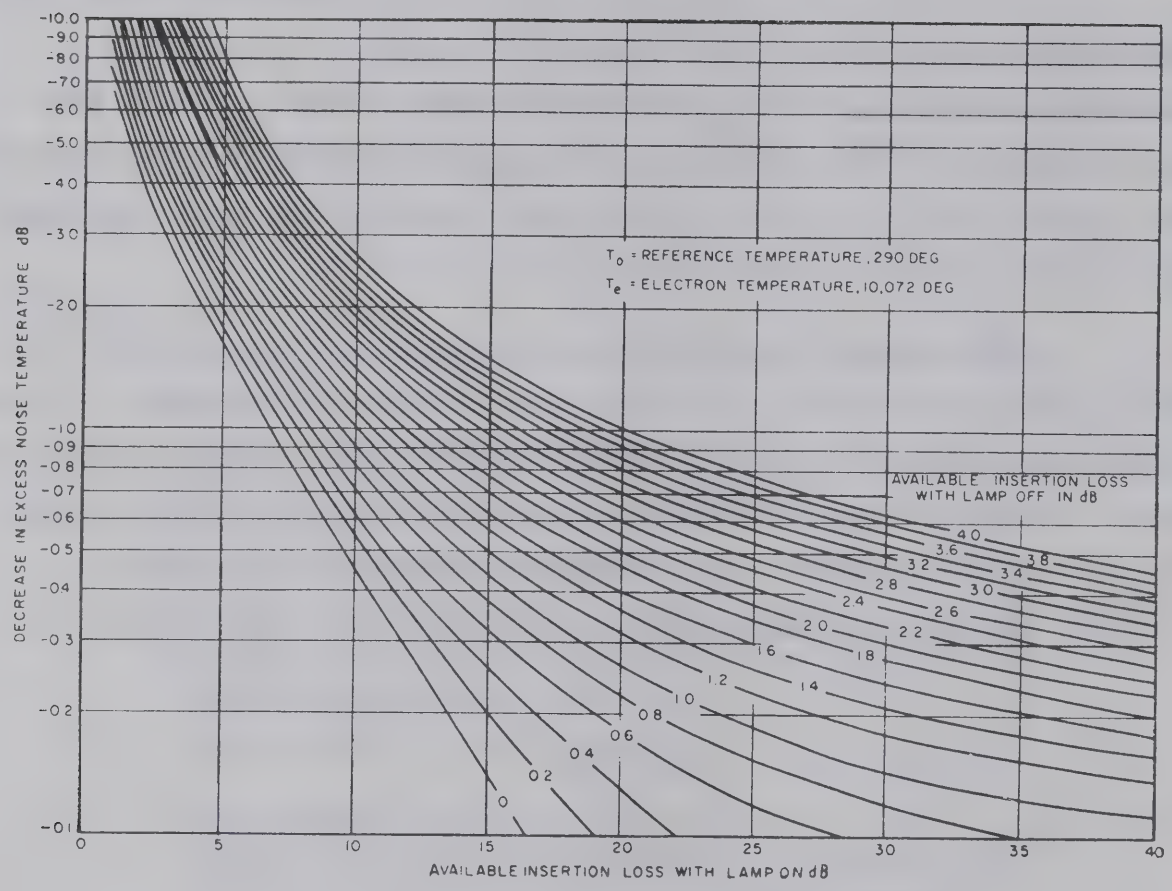


FIGURE 4-7. DECREASE IN RELATIVE EXCESS NOISE TEMPERATURE AS A FUNCTION OF NOISE SOURCE INSERTION LOSS

this uncertainty will cause a direct uncertainty in the noise figure measured. The AIL Type 82 Noise Calibration System will calibrate a noise source to within ± 0.1 dB of a standard (that is, a noise source which can be calibrated by The National Bureau of Standards, such as the AIL Type 80 Noise Standard).

4.8.2 NOISE GENERATOR TERMINATION TEMPERATURE

The definition of noise figure is based on a termination temperature of 290°K (the reference temperature). If this condition is not met, the measured value of noise figure must be corrected. This correction (δ) in dB, determined from Figure 4-8 or equation 4-5, is algebraically added to the measured noise figure (also expressed in dB).

$$\delta = 10 \log \left[1 - \frac{T_1 - T_0}{T_2 \quad T_0} - \frac{T_1 - T_0}{T_0 F_m} \right] \qquad (4\text{-}5)$$

where

T_1 = actual temperature of the termination

T_2 = effective temperature of the noise generator in the ON condition

T_0 = 290°K

F_m = measured noise figure

4.8.3 SWR DIFFERENTIAL

The difference in SWR of the noise generator between the hot (or ON) condition and cold (or OFF) condition may have a significant effect upon the gain and noise figure of some high-gain, negative-input resistance devices (parametric amplifiers, masers, etc.). The change in gain due to source impedance variations for high-gain amplifiers (greater than 15 dB) can be closely approximated by:

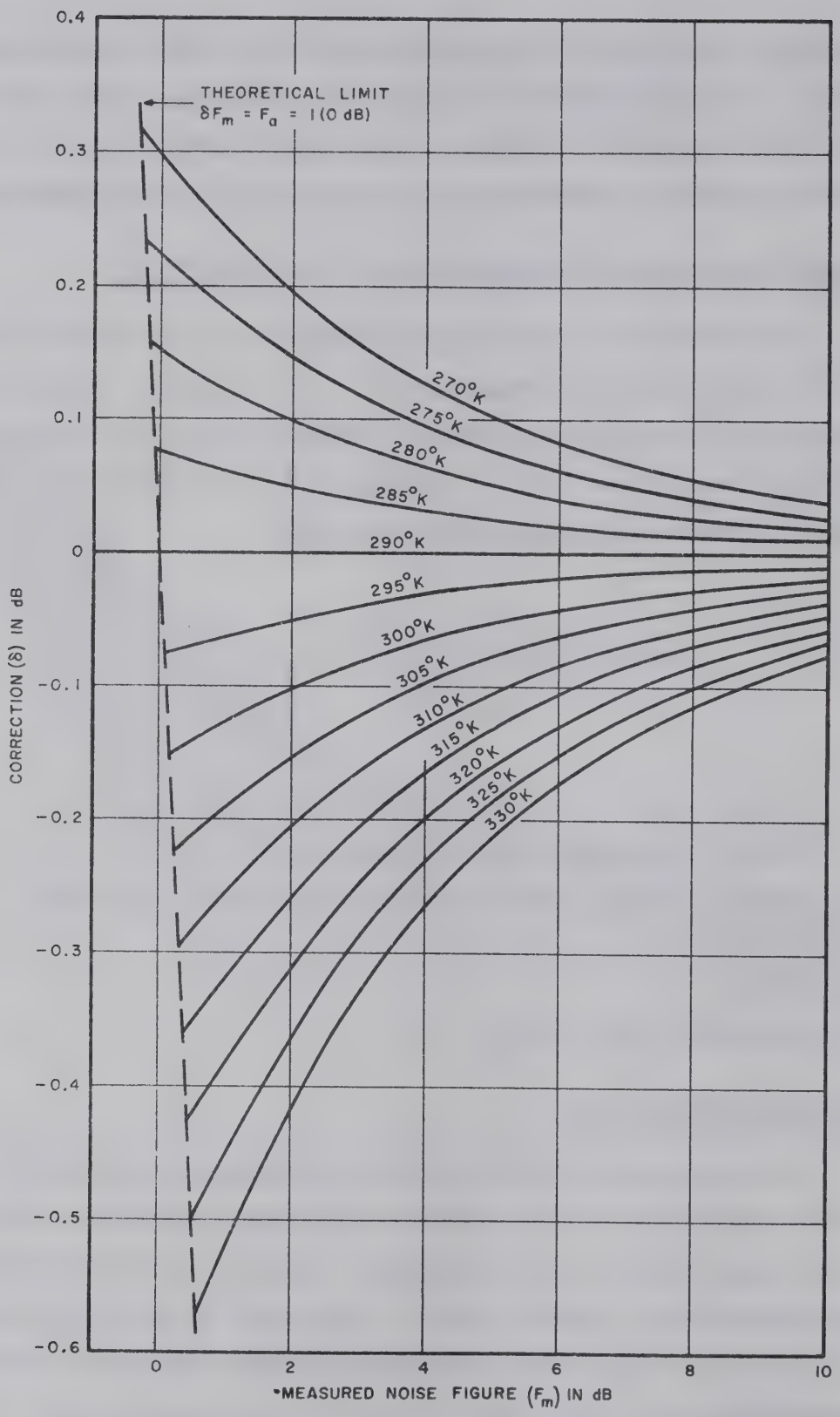


FIGURE 4-8. EFFECT OF TERMINATION TEMPERATURE NOT EQUAL TO 290°K FOR NOISE GENERATOR WITH NOMINAL 15.3-dB EXCESS NOISE RATIO

$$\frac{\Delta G}{G} \approx \frac{\Delta |Z_o|}{|Z_o|} G^{1/2} \qquad (4\text{-}6)$$

where

G = amplifier gain
Z_o = source impedance
ΔG = change in gain
ΔZ_o = change in source impedance

This change in gain will cause an error in the MANUAL or AUTO method of measurement. The true Y factor can be obtained from:

$$Y_{TRUE} = Y_{measured\ (dB)} - \Delta G_{dB} \qquad (4\text{-}7)$$

ΔG can be measured exactly by coupling a test signal into the amplifier input through a 20- or 30-dB directional coupler and observing the output as the noise generator is turned on and off. The test signal power should be at least 20 dB greater than the noise power at the amplifier input, but not large enough to cause limiting in the system.

A second solution would be to provide isolation, by means of a ferrite device, between the amplifier input and the noise source. This would reduce the impedance variation seen by the amplifier. The insertion loss of the isolator would add directly (in dB) to the noise figure of the device under test.

The uncertainty in the measured noise figure, due to changes in the noise performance of the device under test caused by mismatch changes in the noise source, can be estimated by

$$dF_{dB} = \pm \frac{4.34 \frac{dM}{M}}{1 - \frac{1}{Y}} \qquad (4\text{-}8)$$

where

$$\frac{dM}{M} = \frac{(1 + |\Gamma_r|\ |\Gamma_1|)^2}{1 - |\Gamma_r||\Gamma_2|^2} - 1 \qquad (4\text{-}9)$$

where

Γ_r = reflection coefficient of device under test
Γ_1 = reflection coefficient of noise generator in OFF condition
Γ_2 = reflection coefficient of noise generator in ON condition

4.8.4 IMAGE RESPONSE

The following applies only to conventional receiver applications in which the image channel is not normally used to convey information. Image response can be an important factor in the measurement of low-noise systems consisting of a wideband preamplifier followed by a heterodyne receiver. If the preamplifier has nearly equal gain at both the image frequency and the signal frequency, its noise figure will be deteriorated by the amplification of the input noise at the image frequency and a manual Y-factor or automatic noise figure reading will not yield the true noise figure. Equation 4-10 shows the relation between the true noise figure (F_T) and the noise figure measured either manually or automatically.

$$F_T = \left(1 + \frac{G_{im}}{G_{sig}}\right) F_m \qquad (4\text{-}10)$$

where

F_T = true noise figure
F_m = noise figure measured
G_{im} = image channel gain
G_{sig} = signal channel gain

It can be seen that, for a receiver with equal signal and image channel gain, the measured noise figure will be one half (or 3 dB below) the true noise figure.

4.8.5 CABLE LOSS

Any loss introduced between the noise generator and the device under test will cause an apparent change in the excess noise ratio of the generator. These losses should be measured accurately and subtracted (in dB) from the T_{ex} of the generator. This corrected T_{ex} should be used when setting up during the calibration mode of operation, or in the calculations for a manual measurement.

4.8.6 SYSTEM BANDWIDTH

The system bandwidth of a noise figure measuring setup includes the instrument making the measurement, as well as the device under test. Therefore, if an amplifier with a 5-MHz bandwidth were measured with an instrument having a 1-MHz bandwidth, the result will, in general, be an optimistic (or low) noise figure reading. With this condition, it is necessary to make several measurements so as to have measured the spot noise figure of the device under test completely across its band of operation. These numbers are then averaged to give the true noise figure. This error can be eliminated by using an instrument with a bandwidth equal to, or wider, than the device under test.

4.8.7 SECOND STAGE CONTRIBUTION

The equation for the overall noise figure of a two-stage device is

$$F_{12} = F_1 + \frac{F_2 - 1}{G_1} \qquad (4\text{-}11)$$

where all terms are in power ratios, and

F_1 = noise figure of the first stage
F_2 = noise figure of the second stage
F_{12} = overall noise figure of the two stages, and
G_1 = power gain of the first stage

A common error, when making a manual Y-factor measurement as described in paragraphs 4.3, 4.4, and 4.5, is to attempt to make a correction for the insertion loss of the attenuator and the noise figure of the following unit; this is incorrect.

The correct noise figure in a manual Y-factor measurement is given by equation 4-12.

$$F = \frac{T_{ex}}{Y - 1} + \frac{1}{G_1} \qquad (4\text{-}12)$$

where

F = the noise figure of the device under test
Y = the Y-factor
G_1 = gain of the system preceding the attenuator
T_{ex} = excess noise ratio of the noise generator being used

SECTION V

THEORY OF OPERATION

5.1 FUNCTIONAL OPERATION

5.1.1 NOISE FIGURE

Noise figure can be defined as the ratio of the noise power available at the output of a network, when the input termination is at the standard reference temperature (T_o = 290°K), to that which would be available at the output of an ideal noiseless network of otherwise identical characteristics. This can be expressed mathematically as in equation 5-1.

$$F = \frac{N_o}{GN_i} \tag{5-1}$$

By rearranging equation 5-1,

$$N_o = N_i FG \tag{5-2}$$

The noise power available at the input is that generated by the input termination and can be written.

$$N_i = KT_oB \tag{5-3}$$

where

K = Boltzmann's constant = 1.38×10^{-23} joules/°K

B = bandwidth in Hz

T_o = standard reference temperature (290°K)

NOTE

All temperatures in these equations are expressed as absolute temperatures (degrees Kelvin) and are related to the Centigrade scale as follows:

$$^{o}K = ^{o}C + 273$$

Substituting in equation 5-2,

$$N_o = KT_oBFG \qquad (5\text{-}4)$$

Expansion of this relation yields

$$N_o = \left[KT_oB + (F - 1)\, KT_oB\right] G \qquad (5\text{-}5)$$

Although equation 5-5 expresses noise figure implicity in terms of its effect on the network output, it is sometimes considered more basic than equation 5-1 because:

- It can be used to show the effect of an input termination temperature differing from the reference temperature (T_o).
- It can be conveniently represented pictorially.
- It provides the basis for an indirect, but convenient, method of measuring noise figure.

Figure 5-1A is a representation of equation 5-5. Noise source A is the input termination. In addition, noise source B is a fictitious source that represents the network's contribution to the noise output, referred to the input. It should be noted that the definition of noise figure is based on the reference temperature. The effect of varying input termination temperature was discussed previously.

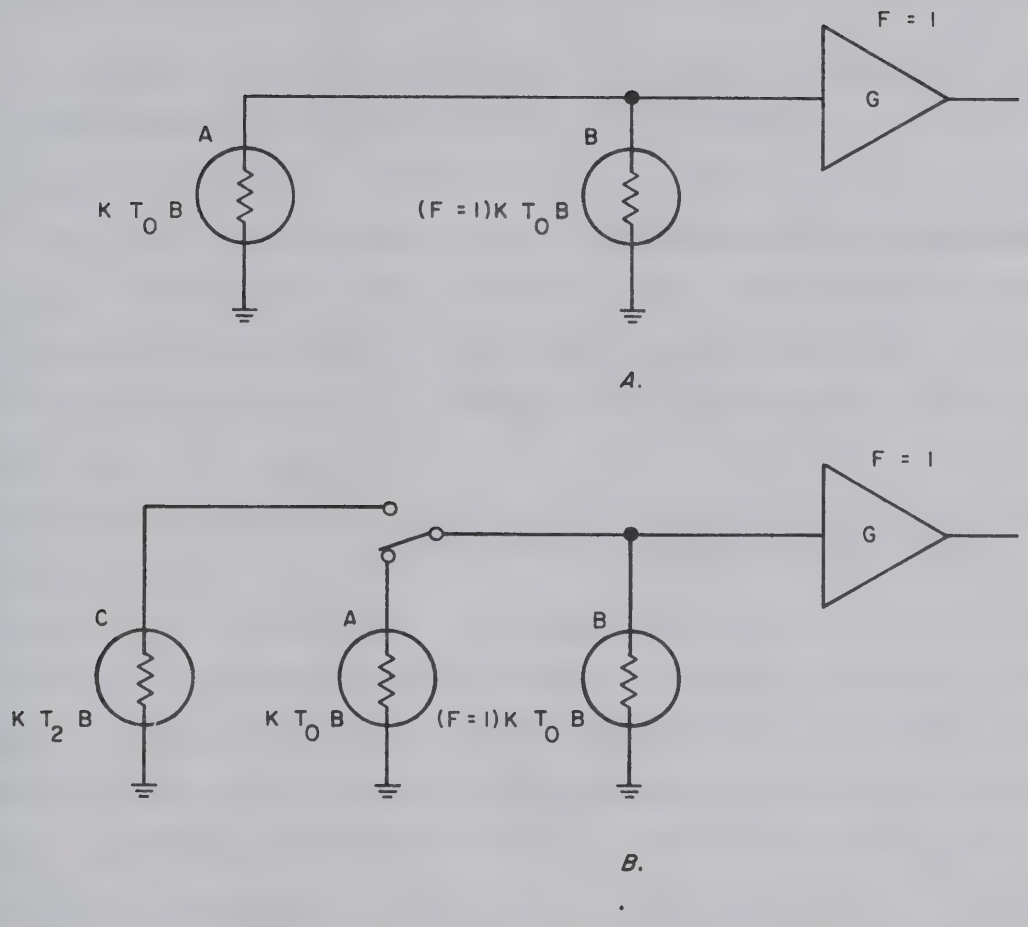


FIGURE 5-1. EQUIVALENT NOISE REPRESENTATION OF A NOISY NETWORK

5.1.2 NOISE FIGURE MEASUREMENT (GENERAL)

Figure 5-1A can be modified as indicated in Figure 5-1B. A switch is added, so that the original input termination (A) can be disconnected and the network input terminated in a second source (C) at a temperature

T_2 (the temperature of the gas-discharge noise generator usually). The available output power of the network for this condition is given by equation 5-6.

$$N_o = \left[KT_2B + KT_oB\,(F - 1)\right] G \tag{5-6}$$

Dividing equation 5-6 by equation 5-4

$$\frac{N_{o2}}{N_{o1}} = \frac{T_2 + T_o\,(F - 1)}{T_oF} \tag{5-7}$$

Adding -1 to both sides and rearranging terms,

$$F = \frac{\left(\frac{T_2}{T_o} - 1\right)}{\left(\frac{N_{o2}}{N_{o1}} - 1\right)} \tag{5-8}$$

Equation 5-8 is the basic relation for determining noise figure. The term $T_2/T_o - 1$ is called "excess noise ratio" and is usually expressed simply as T_{ex}. It represents the relative increase in noise power at the network input when the switch is operated. If T_{ex} is known, the ratio N_{o2}/N_{o1} (commonly called Y-factor) can be measured and the noise figure computed from equation 5-8. Note that it is not necessary to measure the absolute power levels at the network output, merely their ratio.

Therefore,

$$F = \frac{T_{ex}}{Y - 1} \tag{5-9}$$

5.1.3 MANUAL NOISE FIGURE MEASUREMENT

There are several methods of measuring Y-factor and, indirectly, noise figure. However, only the most common method is discussed.

Figure 5-2 is a block diagram showing the basic setup of equipment. The noise generator can be any one of a number of devices of known relative excess noise ratio. The most common are: (1) the gas-discharge lamp, in which the relative excess noise ratio is primarily a function of the type of gas, the diameter of the discharge column, and the gas pressure, (2) the thermionic diode, which has a relative excess noise that is a function of the dc diode current and the terminating source resistance, and (3) the new solid-state noise generators, such as the AIL Type 7001. When the noise generator is turned off, the input of the receiver under test sees a passive termination at T_o and the detector level meter indicates some value indicative of N_{o1} in equation 5-8. When the noise generator is turned on, the output level will increase because of the increase of noise at the input. This new level is indicative of N_{o2}. If the attenuation between the receiver output and the detector is increased until the detector level is the same as with the noise source off, then this increase is the Y-factor (N_{o2}/N_{o1}) expressed in dB (assuming the attenuator is calibrated in dB). This value can then be converted to a power ratio, substituted in equation 5-9, and the receiver noise figure computed.

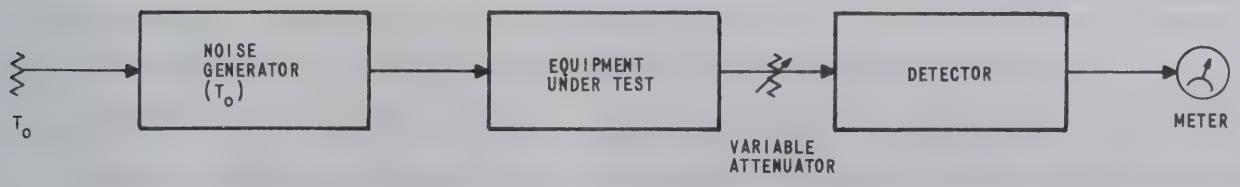


FIGURE 5-2. BLOCK DIAGRAM OF EQUIPMENT SETUP FOR DETERMINING NOISE FIGURE

This method of noise figure measurement is preferred because:

- The signal level entering the detector (usually a test receiver such as the AIL Type 136 Receiver or Type 75, in the manual mode) is kept at a constant level. Nonlinearities, the detector law, etc., are all held constant. In fact, the receiver may be operated in a nonlinear, or partially saturated condition. The only effect this has upon the measurement is a reduction in the resolution of the meter.
- The noise figure of the detector (or receiver) and the insertion loss of the attenuator make no contribution to the noise figure of the device under test. Again, the only effect a high insertion loss and high receiver noise figure has upon the measurement is a loss of resolution.
- If the meter change was read (in dB or any convenient ratio) instead of keeping its level constant, then the system must be checked very accurately for nonlinearities. Also, the meter must be calibrated over the range it is expected to operate.

5.1.4 AUTOMATIC NOISE FIGURE MEASUREMENTS

The preceding paragraphs derived the procedure for performing manual noise figure measurements. It is evident that, if a large number of measurements are required, or if the noise figure is being used as a measure of system performance while the system is being tuned or set up, these methods can become quite cumbersome and time consuming. The basic elements of the Precision Automatic Noise Figure Indicator are shown in general block form in Figure 5-3.

The first requirement for this type of system is a method of periodically turning the noise generator on and off. This is accomplished by a modulator driven by a gate generator, usually a free running square-wave generator (multivibrator) operating at a low audio frequency. The output of the receiver consists of square-wave modulated noise. As in the manual measurement, the two levels of this square wave represent the

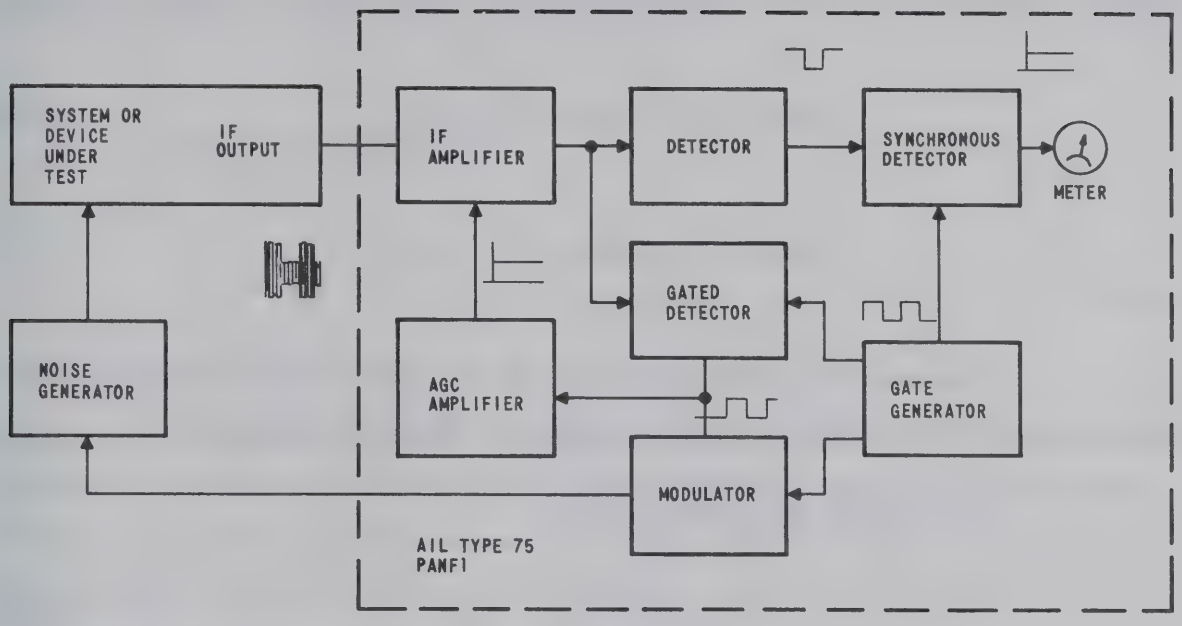


FIGURE 5-3. BLOCK DIAGRAM OF TYPE 75 PANFI

device-under-test (DUT) noise and the DUT plus generator noise. This signal is amplified in the IF amplifier and detected in a square-law detector. A sample of this modulated noise signal is also detected in a second detector which is gated to provide an output only during the time the noise generator is turned off. When the noise generator is turned on, the detector is gated off. Its output is then converted to a dc signal proportional to this noise-off condition. This dc signal is then amplified and applied to the IF amplifier in such a manner as to keep the noise-off level at the output of the IF amplifier constant.

The square-law detector provides an output voltage proportional to the input power. This output will consist of two voltage levels (V_1 and V_2), proportional to the two levels of noise power at the input to the IF amplifier.

$$\text{Noise-on voltage: } V_2 = pN_{o2} \tag{5-10}$$

$$\text{Noise-off voltage: } F_1 = pN_{o1} \tag{5-11}$$

The peak-to-peak amplitude of the square wave is measured by the synchronous detector and the resultant voltage is indicated by the meter.

Therefore, the meter voltage

$$V_m = c\,(V_2 - V_1) \tag{5-12}$$

From equations 5-10 and 5-11

$$V_m = p\,(N_{o2} - N_{o1}) \tag{5-13}$$

Rearranging terms

$$V_m = pN_{o1}\left(\frac{N_{o2}}{N_{o1}} - 1\right) \tag{5-14}$$

From the previous discussions

$$\frac{N_{o2}}{N_{o1}} = Y$$

Therefore,

$$V_m = pN_{o1} (Y - 1) \qquad (5\text{-}15)$$

From equation 5-9

$$V_m = pN_{o1} \frac{T_{ex}}{F} \qquad (5\text{-}16)$$

Equation 5-16 indicates that, if T_{ex} is known and N_{o1} is constant (a condition satisfied by the gated detector and AGC amplifier), the meter voltage is inversely proportional to the noise figure of the device under test. This is a highly desirable result since lower noise figures read closer to full scale and thus greater resolution is achieved.

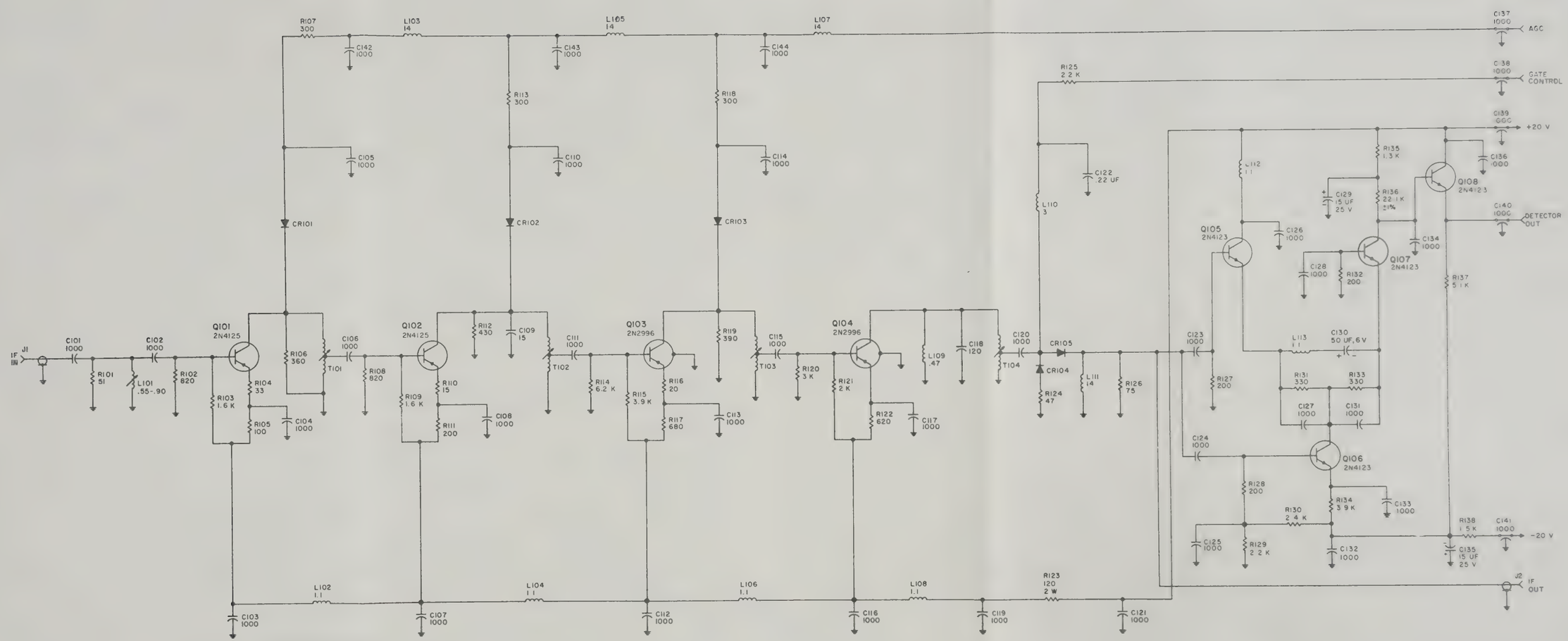
Note also that because a square-law detector is used, the meter scale, when calibrated in dB, becomes logarithmic, and thus produces a natural expansion on the upper half of the scale (where low noise figures are indicated).

5.2 CIRCUIT DESCRIPTION

5.2.1 IF-AMPLIFIER-DETECTOR (P/N 212875)

The function of this module is the amplification of the incoming noise signal to a level that may be detected in the square-law detector and processed by following circuits. The IF gain of this amplifier is controlled, during the automatic and calibrate mode of operation, by the noise from the system under test (when the noise generator is turned off).

The module is composed of three subsections as discussed in the following paragraphs. (Refer to schematic Figure 5-4.)



UNLESS OTHERWISE NOTED:

RESISTANCE VALUES IN OHMS, ½ WATT
CAPACITANCE VALUES IN PF
INDUCTANCE VALUES IN UH
DIODES ARE TYPE HPA3039

T66ZX001-010A

FIGURE 5-4. SCHEMATIC DIAGRAM OF IF-AMPLIFIER DETECTOR

FIGURE 5-5 DELETED

5.2.1.1 30-MHz AMPLIFIER

The 30-MHz amplifier section consists of four transistor stages arranged in a common-emitter configuration. These are synchronously tuned to 30 MHz, with an overall bandwidth of 5 MHz. Interstage coupling is achieved using auto-transformers which provide the proper impedance matching for the desired bandwidth and stability.

Three PIN diodes (CR101, 102, and 103) are used to provide gain control on the first three stages. As the current in these diodes is increased, their conductance increases, shunting the signal to ground and thereby reducing the stage gain. These diodes provide more than 65 dB of gain control range and are used in all modes of operation (automatic, manual, and calibrate). The first three stages are designed to have a bandwidth greater than 20 MHz to prevent changes in the overall bandwidth or center frequency as the gain is adjusted. The first two stages use heavy emitter degeneration and are operated at a relatively high current to prevent saturation when the input signal level is high and the gain is turned down near its minimum point. Input signal levels having peak value of 0 dBm can be handled by this amplifier when the gain is decreased fully. This is required by the 65-dB dynamic range of the Type 75 PANFI.

5.2.1.2 DIODE SWITCH

The second basic section of this module is the diode switch composed of two PIN diodes arranged in such a manner that, with the application of a positive voltage to C138, the shunt diode (CR104) is biased off (a high impedance) and the series diode (CR105) is biased on (a low impedance), thereby allowing the signal to pass. When a negative voltage is applied, the diodes reverse their operation and provide, typically, 40 dB of signal reduction.

During the automatic mode of operation, the switch is opened during the first 200 μsec of the noise generator on-time. This prevents the PANFI from being sensitive to variations of noise generator turn-on time.

During the manual operation, this switch is alternately turned on and off at approximately a 400-Hz rate. This provides a 400-Hz modulated noise signal that can be presented on the meter by the synchronous detector, thus allowing the noise generator to be operated in a CW condition and permitting a true manual measurement.

5.2.1.3 SQUARE-LAW DETECTOR

The third and final section of this module is the square-law detector. This device consists of a differential amplifier pair (Q105 and Q107) whose current is supplied from a second amplifier (Q106). One side of the differential amplifier is grounded; the other side is driven from the same signal source as Q106. The result is that the output current flowing in R135 and R136 is the square of the input voltage (or current). This signal is then coupled to the output through an emitter follower which prevents the video amplifier from loading the detector.

5.2.2 AGC IF AMPLIFIER AND DETECTOR (P/N 212881)

During the automatic and calibrate modes, this module produces an output proportional to the level of the noise-off signal. This output is amplified by the AGC amplifier and used to hold the gain of the IF amplifier constant. During the manual mode, it provides additional IF gain. It is composed of three basic units as discussed in the following paragraphs. (Refer to schematic Figure 5-6.)

5.2.2.1 30-MHz AMPLIFIER

This amplifier is an RC-coupled, three-stage, feedback amplifier designed for broadband stable operation. The bandwidth and gain are

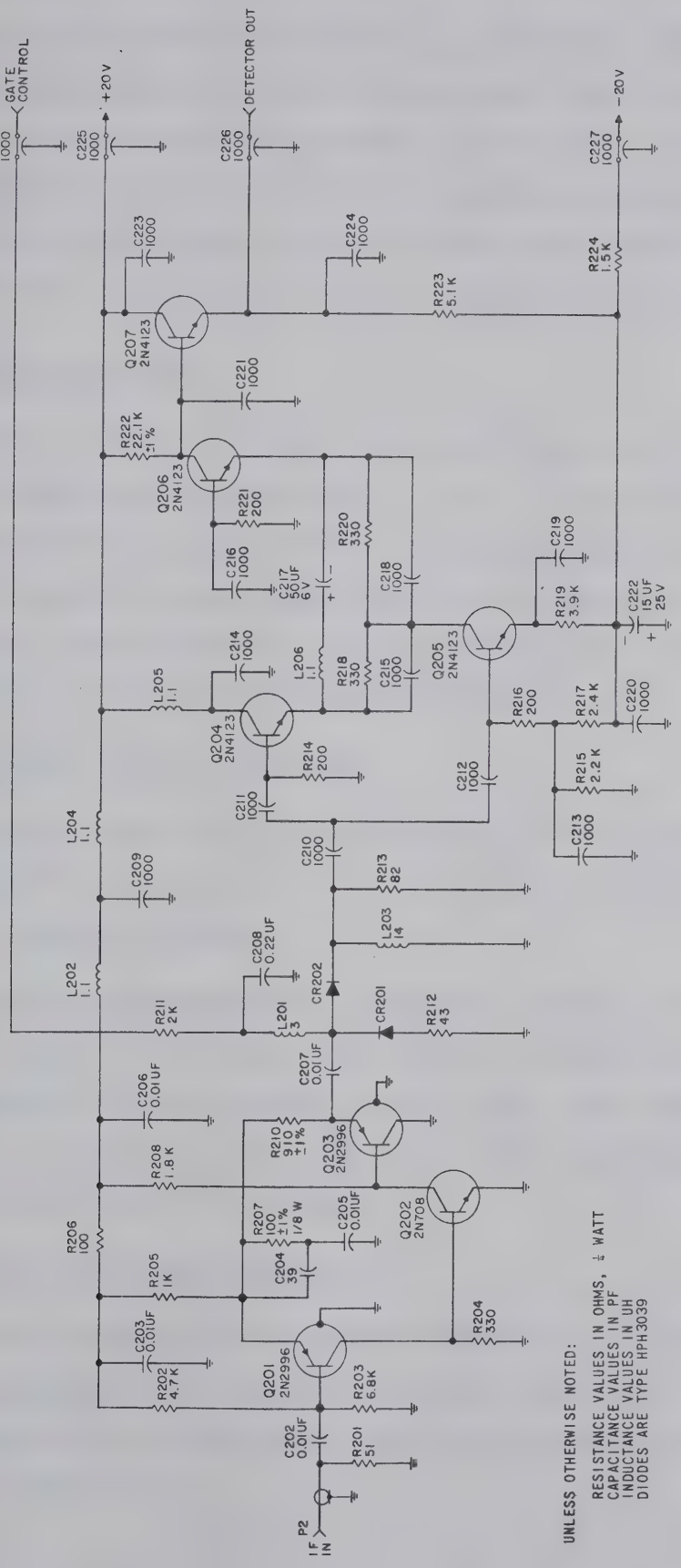


FIGURE 5-6. SCHEMATIC DIAGRAM OF AGC IF AMPLIFIER/DETECTOR

FIGURE 5-7 DELETED

determined by the feedback circuit composed of R210, R207, and C204; this results in a bandwidth greater than 60 MHz and a gain of 20 dB. A feedback amplifier is used because of its inherent gain stability. If the gain were to vary, the AGC voltage controlling the IF amplifier-detector would change, causing an error in the noise figure indicated on the meter. The dc operating points of the three stages are stabilized by using dc feedback.

5.2.2.2 DIODE SWITCH

The diode switch that follows the 30-MHz amplifier is identical to the switch discussed in paragraph 5.2.1.2. In the automatic and calibrate modes, this switch alternates between a high and low loss, at a 400-Hz rate. It is driven in such a manner that it is in the low-loss position during the noise-off time, thereby allowing the following circuits to respond only to the noise-off signal, while ignoring the noise-on signal.

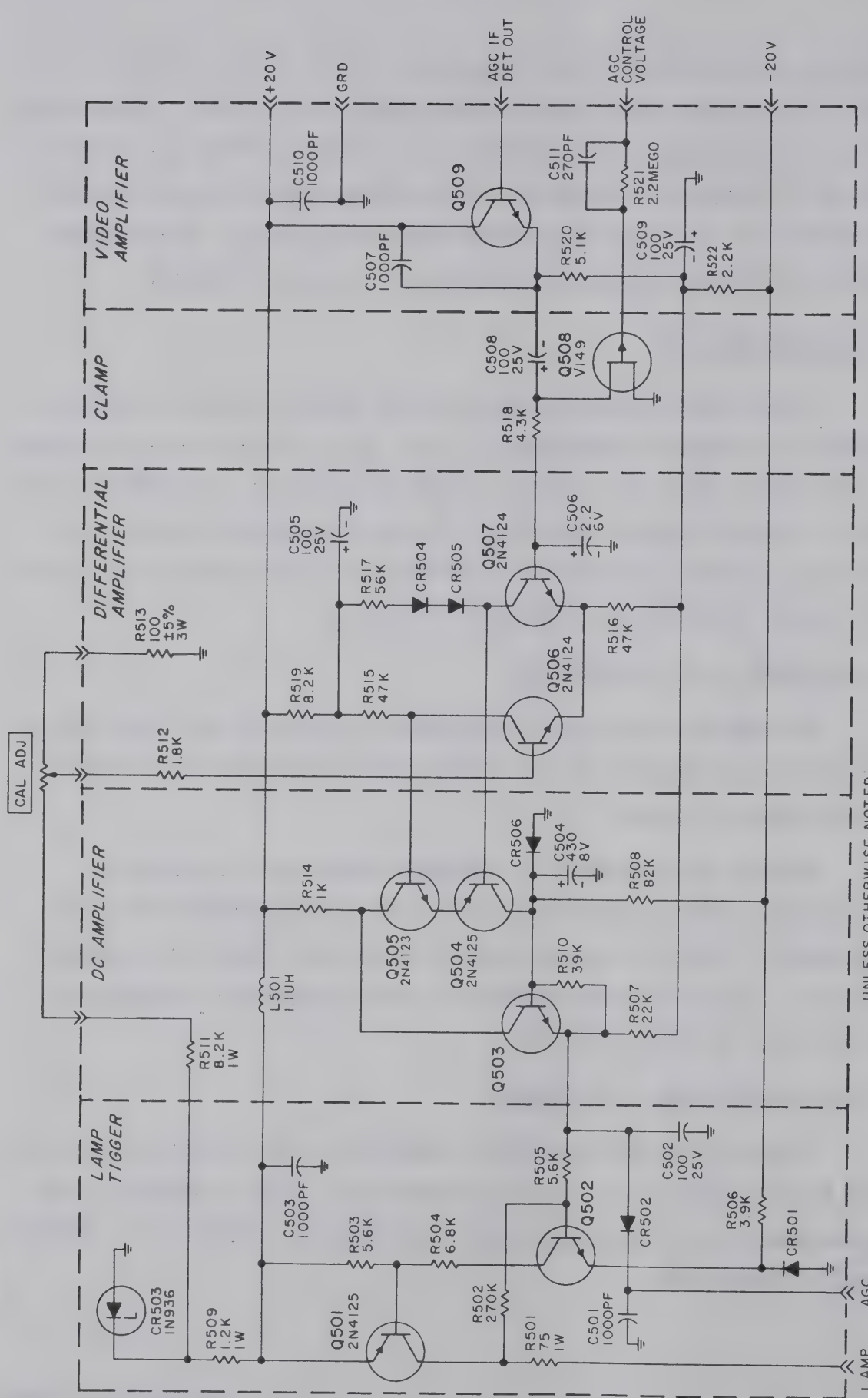
5.2.2.3 SQUARE-LAW DETECTOR

The square-law detector operates in identically the same way as that discussed in paragraph 5.2.1.3. Its output is a 400-Hz signal proportional to the noise-off signal.

During the automatic or calibrate operation, this signal is processed by the AGC amplifier to provide a dc output proportional to the noise-off signal. When the manual mode is used, the output of the square-law detector is connected to the input of the video amplifier-synchronous detector and used to drive the meter.

5.2.3 AGC AMPLIFIER (P/N 212935)

This unit accepts the 400-Hz output from the square-law detector, described in paragraph 5.2.1.3, and produces a dc output capable of controlling the gain of the IF amplifier described in paragraph 5.2.1.1. (Refer to schematic Figure 5-8.)



UNLESS OTHERWISE NOTED:
RESISTANCE VALUES IN OHMS, 1/4 WATT
CAPACITANCE VALUES IN UF
TRANSISTORS ARE TYPE 2N4123
DIODES ARE TYPE IN2071

FIGURE 5-8. SCHEMATIC DIAGRAM OF AGC AMPLIFIER

FIGURE 5-9 DELETED

During the automatic and calibration modes, the 400-Hz detector output is connected to the base of Q509 (E507), an emitter-follower used to prevent loading of the square-law detector. The output of Q509 is applied to an integration network (R518 and C506), which converts the 400-Hz signal to a dc voltage. Q508 is a p-channel FET which clamps the signal entering R518 to ground during the noise-on time. This restores the dc level to the signal, lost by ac coupling in previous circuits. The integrated dc signal is applied to one side (Q507) of a differential amplifier pair (Q507 and Q506). This differential amplifier compares this input voltage to a level preset by R511, R901, and a stable zener diode (CR503). When this input level is greater than that set by R901, the difference in the collector voltages of Q506 and Q507 is amplified by Q503, Q504, and Q505, producing a positive voltage at E502. This is applied to the gain control diodes in the IF amplifier-detector module. This output voltage will vary between approximately 0 volt (no gain control) and +2 volts (65-dB gain reduction).

When the input level to the AGC amplifier exceeds the preset level, thereby producing a positive output voltage, Q502 is turned on, which in turn causes Q501 to conduct. When Q501 conducts, DS901 (the AGC light on the front panel) illuminates, indicating that the input level to the Type 75 PANFI is high enough for the AGC circuits to control the operation and thus hold the noise-off signal constant. When Q501 conducts, Q502 and the entire indicator circuit is locked-up by regenerative action, until the input signal is removed. R901 is used to change the preset voltage during the calibration mode. This varies pN_{01} of equation 5-16 and creates the same effect as if T_{ex} were varied.

5.2.4 VIDEO AMPLIFIER-SYNCHRONOUS DETECTOR (P/N 212920)

This module amplifies the 400-Hz output of the square-law detector and produces a current in the dc meter which is proportional to the

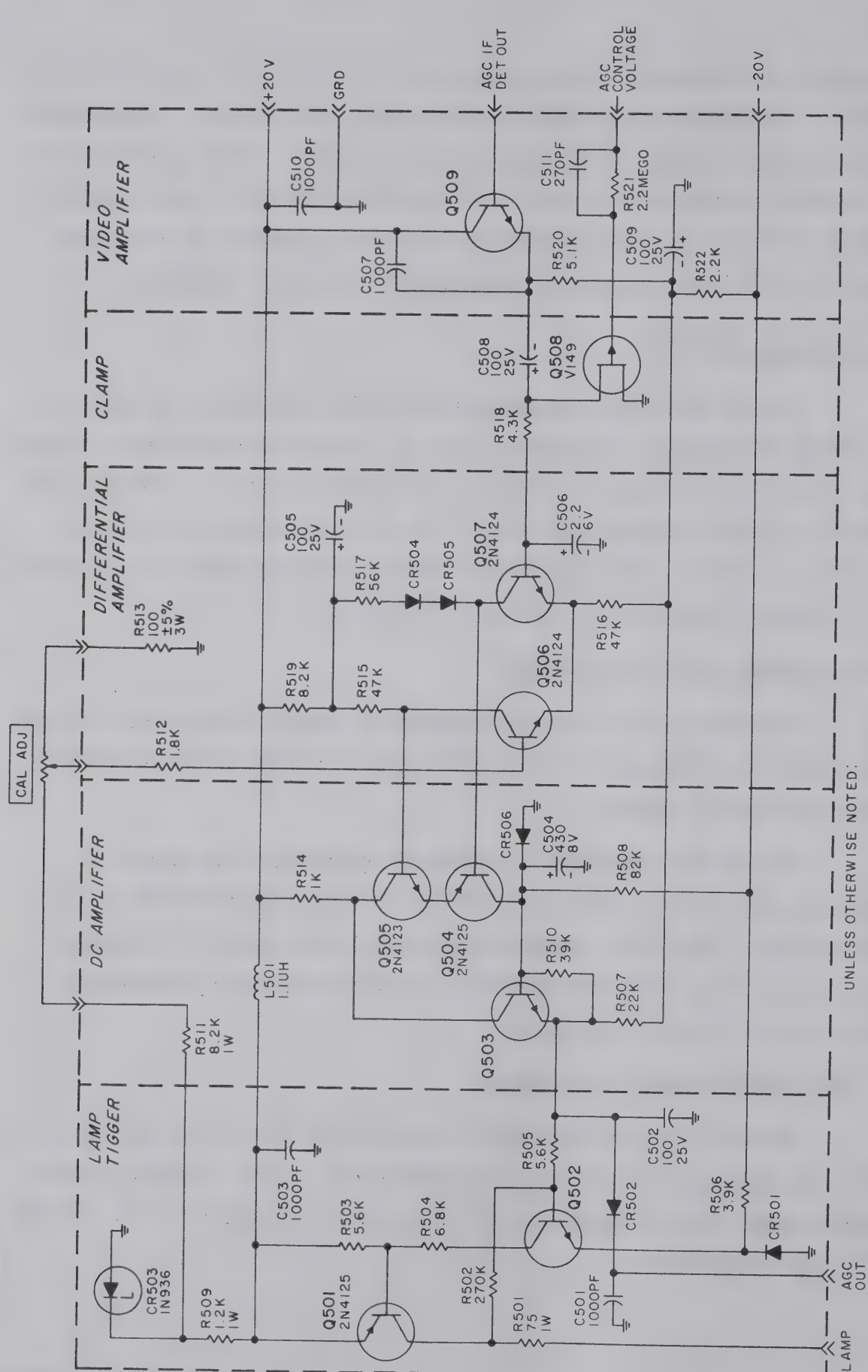


FIGURE 5-8. SCHEMATIC DIAGRAM OF AGC AMPLIFIER

Management Data Response for NSN 6625-00-170-6261

Item Name: METER,NOISE LEVEL

PMI: U ADP: 0 CC: X DML: A ESDC: A HMIC: P

OK

S/A	SOS	AAC	QUP	UI	Unit Price	SLC	CIIC	RC	MGMT CTL
PC	Phrase	Statement			UI Conv Factor		OOU	JTC	D043
DF	FPZ	X	1	EA	3172.00	0	U	S	--M---N
R	REFER TO XNCD418054SA								

Reference Number Data Response for NSN 6625-00-170-6261

Item Name: METER,NOISE LEVEL

TYPE II: 1 INC: 48206 HCC:

Part Number	CAGE	I S C	RN CC	RN VC	D A C	RN AAC	SADC
07512C	00752	2	3	2	4	SB	

Freight Data Response for NSN 6625-00-170-6261

Item Name: METER,NOISE LEVEL

IC	ACTY	NMFC ITEM NUMBER	SUB	UFC ITEM NUMBER	RV	HMC

ÿ

LTL	LCL	WCC	TCC	SHC	ADC	ACC	ASH

ÿ

National Freight Motor Description

ÿ□

Air Force Transportation Data

EFF DATE	NMFC	FRC	TCC	SPI DATE	SPII	SPI #
91104	136740	J	Z	91086	T	000003XF1

Supplier Data Response for NSN 6625-00-170-6261

Item Name: METER,NOISE LEVEL

CAGE Code: 00752 Status: A Type: A CAO: S3309A ADP: SC1012

Company Name and Address:
AIL SYSTEMS INC SUB OF EATON CORP
450 COMMACK RD

DEER PARK NY 11729-4591 Phone: 516-595-5000
UNITED STATES FAX: 516-595-5566

RPLM Code: ASSOC Code: 81118 AFFIL Code: S
SIZE: E Primary Business: J Type of Business: N Women Owned: N
SIC Codes: 1721

Supplemental AF Management Data Response for NSN 6625-00-170-6261
Item Name: METER,NOISE LEVEL

SUPPLEMENTAL MANAGEMENT DATA

EMC	SFIC	PSC	A/L	U/I	CF	PRE U/I	CIC	DATE CIC	MOE	NIMSC	MDC	ESC	LLC
4		5							FEE4	F		UC	

IM NAME: VACANT UBJ - Heather Hill
IM SYMBOL/DSN: LDAK /AV 945-7231

> Mr. Reynosa
> 945-6134

RECOVERABLE ITEM MOVEMENT CONTROL SYSTEM (RIMCS) DATA

EFF DATE	CC	PRI	IM/SM	SRAN#1	SRAN#2	SRAN#3	M/F	PC	OC

MSD Prices/Costs Response for NSN 6625-00-170-6261
Item Name: METER,NOISE LEVEL

There is no information available.

Characteristics Data Response for NSN 6625-00-170-6261

Item Name: METER,NOISE LEVEL

MRC	Requirement Statement	Clear Text Reply
NAME	ITEM NAME	METER,NOISE LEVEL
AACT	CIRCUIT CURRENT FOR WHICH DESIGNED	AC
ABHP	OVERALL LENGTH	20.125 INCHES NOMINAL
ABKW	OVERALL HEIGHT	8.000 INCHES NOMINAL
ABMK	OVERALL WIDTH	19.750 INCHES NOMINAL
ACZB	FREQUENCY RATING	50.0 HERTZ MINIMUM AND 400.0 HERTZ MAXIMUM
AMKD	INDICATOR TYPE	DIAL W/POINTER
AMQY	INSTALLATION DESIGN	BENCH
APMM	DIAL SCALE MARKING COLOR	BLACK SINGLE INDICATOR SINGLE RANGE
APPN	ACCURACY IN PERCENT	-0.1/0.1 AT FULL SCALE SINGLE INDICATOR SINGLE RANGE
ASSS	POINTER COLOR	BLACK SINGLE INDICATOR SINGLE RANGE
BHDC	SCALE GRADUATION TYPE	NONLINEAR SINGLE INDICATOR SINGLE RANGE
BHMW	MEASUREMENT RANGE	0.010/10.000 GIGAHERTZ SINGLE INDICATOR 1ST RANGE
BHMW	MEASUREMENT RANGE	0.000/33.000 GIGAHERTZ SINGLE INDICATOR 2ND RANGE
BLSB	SCALE SELECTION METHOD	SWITCH
CBBL	FEATURES PROVIDED	PORTABLE
CTWN	OPERATING VOLTAGE RATING IN VOLTS	115.0 AC MINIMUM AND 230.0 AC MAXIMUM
FAAZ	PHASE	SINGLE
FEAT	SPECIAL FEATURES	SELF-CALIBRATION FOR 10 MHZ TO 40 GHZ NOISE SOURCES, 5 SELECTABLE RANGES, SIGNAL STRENGTH AND OVERRANGE INDICATOR, CAN USE AILTECH 76 SERIES SOLID STATE NOISE SOURCES OR SERIES 70 GAS-DISCHARGE NOISE GENERATORS
STYL	STYLE DESIGNATOR	D1 RECTANGULAR OR SQUARE
SUWT	UNIT OF ISSUE WEIGHT	31.000 POUNDS

FIGURE 5-9 DELETED

During the automatic and calibration modes, the 400-Hz detector output is connected to the base of Q509 (E507), an emitter-follower used to prevent loading of the square-law detector. The output of Q509 is applied to an integration network (R518 and C506), which converts the 400-Hz signal to a dc voltage. Q508 is a p-channel FET which clamps the signal entering R518 to ground during the noise-on time. This restores the dc level to the signal, lost by ac coupling in previous circuits. The integrated dc signal is applied to one side (Q507) of a differential amplifier pair (Q507 and Q506). This differential amplifier compares this input voltage to a level preset by R511, R901, and a stable zener diode (CR503). When this input level is greater than that set by R901, the difference in the collector voltages of Q506 and Q507 is amplified by Q503, Q504, and Q505, producing a positive voltage at E502. This is applied to the gain control diodes in the IF amplifier-detector module. This output voltage will vary between approximately 0 volt (no gain control) and +2 volts (65-dB gain reduction).

When the input level to the AGC amplifier exceeds the preset level, thereby producing a positive output voltage, Q502 is turned on, which in turn causes Q501 to conduct. When Q501 conducts, DS901 (the AGC light on the front panel) illuminates, indicating that the input level to the Type 75 PANFI is high enough for the AGC circuits to control the operation and thus hold the noise-off signal constant. When Q501 conducts, Q502 and the entire indicator circuit is locked-up by regenerative action, until the input signal is removed. R901 is used to change the preset voltage during the calibration mode. This varies pN_{o1} of equation 5-16 and creates the same effect as if T_{ex} were varied.

5.2.4 VIDEO AMPLIFIER-SYNCHRONOUS DETECTOR (P/N 212920)

This module amplifies the 400-Hz output of the square-law detector and produces a current in the dc meter which is proportional to the

difference in the two levels. The unit is composed of two sections, an amplifier and a detector, with a feedback loop around the two. (Refer to schematic Figure 5-10.)

The video amplifier utilizes both ac and dc feedback for highly stable operation. There are essentially three feedback paths. The first is a dc feedback path through R315 to the base of Q301 which stabilizes the dc operating points of the transistors. The second is an ac path from the center tap of T301 through a variable resistor in the emitter of Q304. This eliminates zero offset on the meter due to transformer or diode imbalances, and provides a means of changing meter scales by increasing the gain of the amplifier (decreasing the feedback). The third feedback path is both an ac and a dc path through Q303, R308, and R306. This provides both ac and dc stability in order to reduce errors during the measurement.

A 40 volt peak-to-peak reference signal is applied to E308 and E309 (primary of transformer T301) in synchronism with the 400-Hz signal appearing at the input to the video amplifier (E302). Assume that the polarity of this signal is such that the secondary of the transformer has a positive polarity on pin 5 with respect to pin 3. This signal biases CR301 and CR303 on, and CR302 and CR304 off.

The signal appearing at the input of the video amplifier is amplified and applied to the detector section through Q306 and Q307. These two transistors form an emitter follower with a large negative and positive output capability. Assume that the signal to be measured is positive at the output of C310. The current which flows will split, with approximately half flowing through R318 and half through R319. Since CR302 and CR304 are turned off, the current flowing through R319 must return through the meter and rejoin the current which is flowing out of R318. This current again splits and flows through CR301 and CR303 (the ON diodes) and into opposite ends of the transformer secondary (T301). The two currents then add again

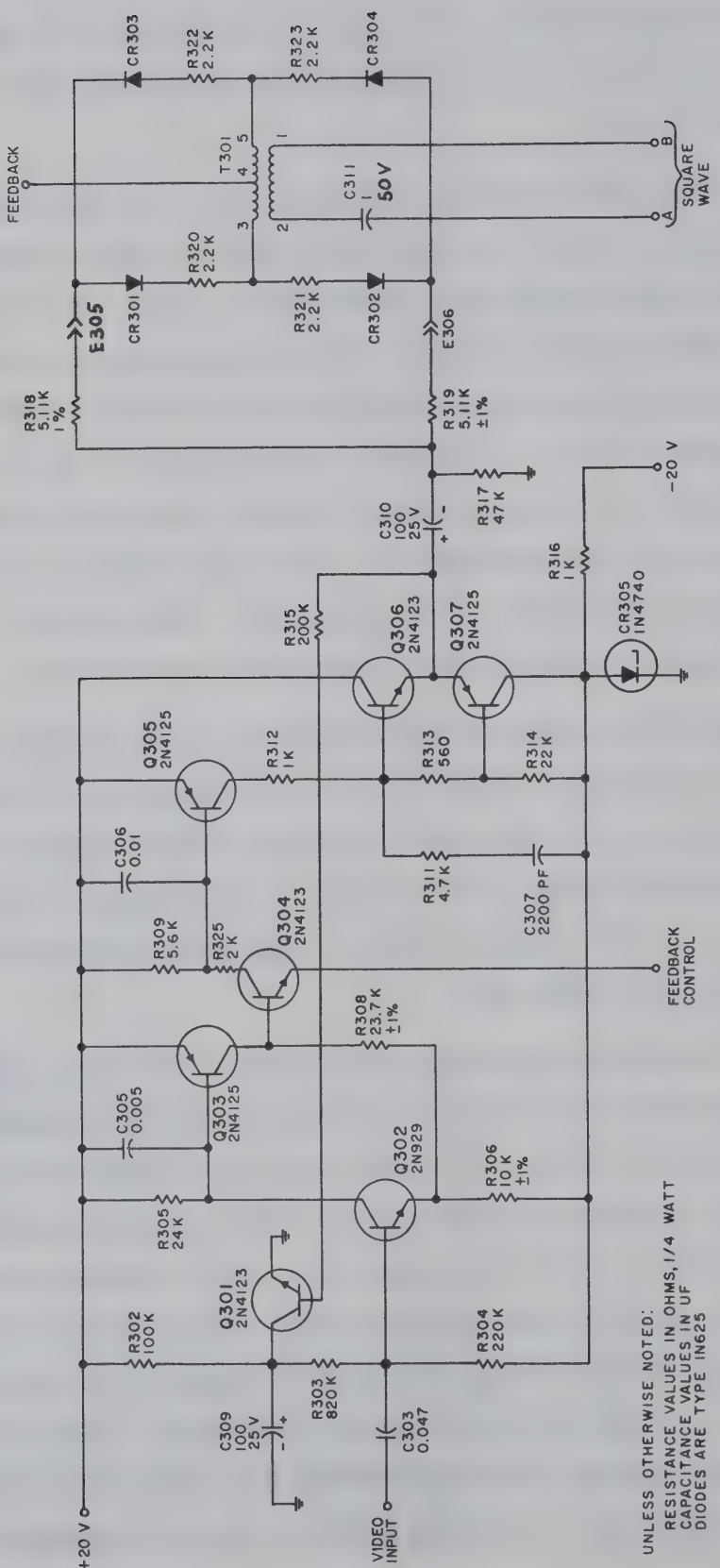


FIGURE 5-10. SCHEMATIC DIAGRAM OF VIDEO AMPLIFIER SYNC DETECTOR

FIGURE 5-11 DELETED

at the center tap and flow to ground through the feedback resistors chosen by S902A. It is this feedback path from the transformer of T301 back to the emitter of Q304 which linearizes the current flowing in the meter by eliminating any zero offset currents.

When the input signal is negative at E302, the 40-volt signal applied to T301 is also reversed, causing CR301 and CR303 to turn off, and CR302 and CR304 to turn on. The signal currents will then flow in the opposite direction to that previously described. The result of turning the opposite diodes on is to cause half of this negative current to flow through the meter in the same direction as the positive signal current.

Resistors R320, R321, R322, and R323 are used to develop sufficient voltage to keep the off diodes turned off for any expected level of input signal.

5.2.5 MULTIVIBRATOR (P/N 212925)

The multivibrator module is the basic timing generator of the Type 75 PANFI. It is made up of two basic subassemblies. (Refer to schematic Figure 5-12.)

5.2.5.1 ASTABLE MULTIVIBRATOR

This subunit consists of transistors Q603, Q604, Q605, Q606, and Q607. It provides a 400-Hz square-wave output. The output (from E602) is used to drive the diode gates in both the IF amplifier and the AGC IF amplifier-detector. The transformer (T301) in the synchronous detector is connected across both E602 and E606, which provides the necessary 40-volt square wave. A third low impedance output (from the emitter follower Q603) drives the FET clamp (Q508) in the AGC amplifier and the modulation circuits in the gas-discharge noise generator control and ignition module. Each output is a square wave of approximately 18 volts peak-to-peak magnitude, and a 400-Hz

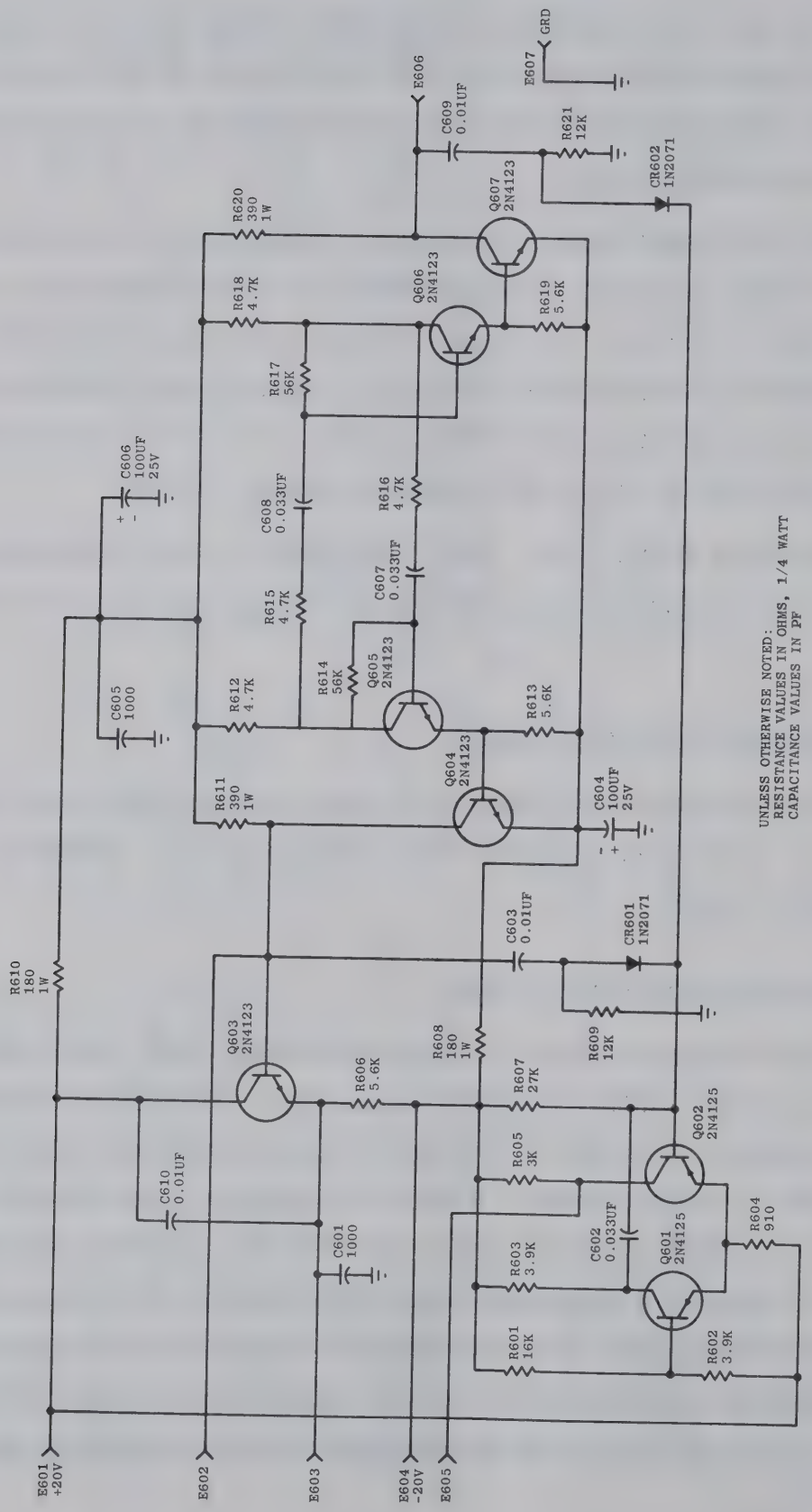


FIGURE 5-12. SCHEMATIC DIAGRAM OF MULTIVIBRATOR

FIGURE 5-13 DELETED

PAGE 5-25 THRU 5-26 DELETED

frequency, which is determined by R612, R615, R616, R618, C607, and C608. The exact frequency is not critical and slight changes will not affect the operation of the PANFI.

5.2.5.2 MONOSTABLE MULTIVIBRATOR

This unit is composed of transistors Q601 and Q602, and is triggered through gating diodes CR601 and CR602. During the automatic mode of operation, its output opens the diode switch during the first 200 μsec of noise-on time (as described in paragraph 5.2.1.2).

The output signals appearing at the astable multivibrator outputs (E606 and E602) are differentiated by C609 and R621, and C603 and R609, respectively, thus producing positive and negative impulses at the leading and trailing edges of the 400-Hz square wave. The positive impulses, coupled through the gating diodes, trigger the monostable multivibrator. The output is a -20 volt pulse of 200 μsec duration which causes the diode switch to open (high-loss condition). When the monostable multivibrator is in its rest state, the output is a constant 5 volts, thereby keeping the switch in its low-loss condition.

5.2.6. GAS NOISE GENERATOR POWER SUPPLY (P/N 213277)

The gas noise generator power supply is used, in conjunction with the ignition module (paragraph 5.2.7) and several chassis-mounted components to ignite, sustain, or modulate a gas-discharge noise generator during the automatic or manual modes of operation. This module is composed of two basic subunits. (Refer to schematic Figure 5-14.)

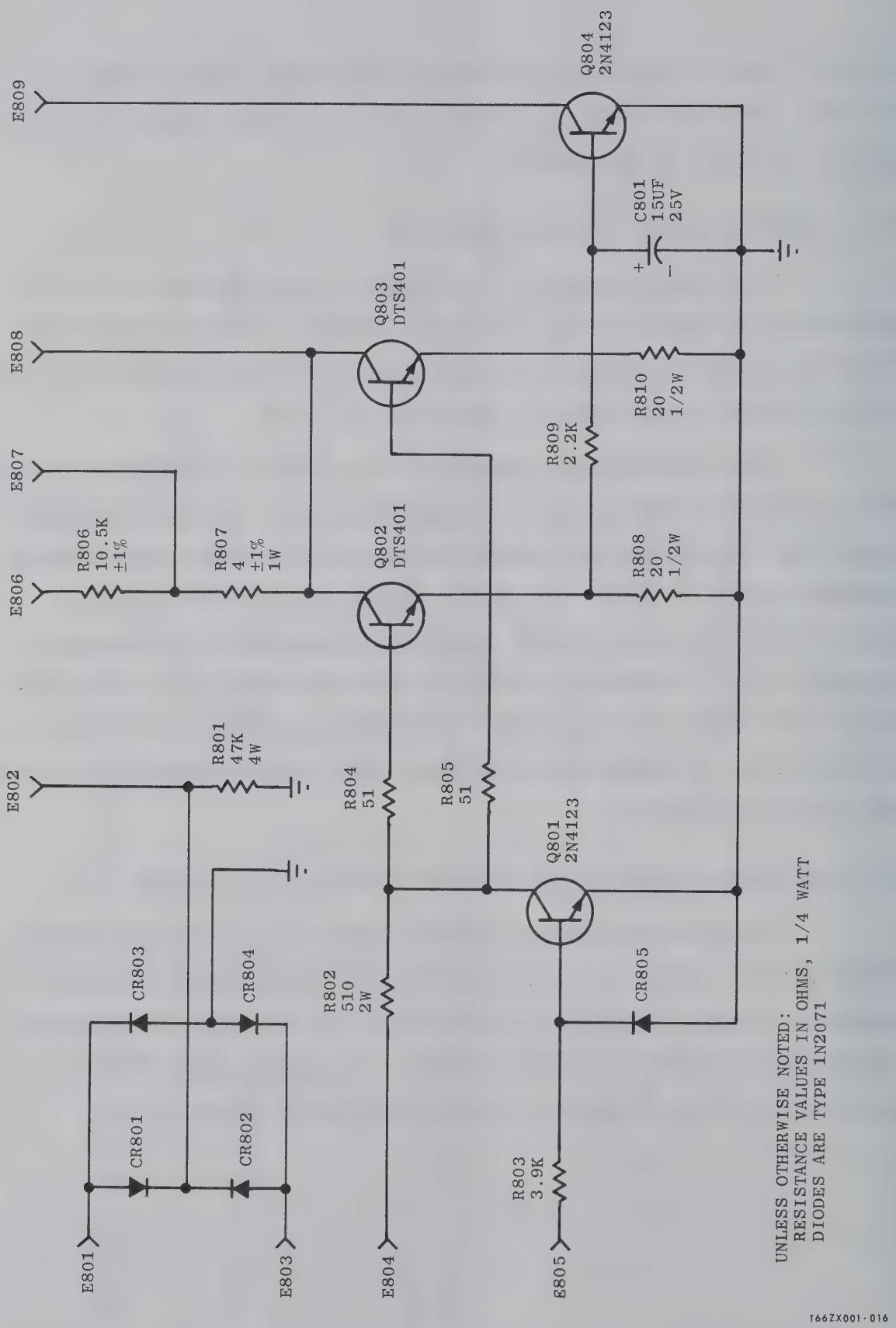


FIGURE 5-14. SCHEMATIC DIAGRAM OF GAS NOISE GENERATOR POWER SUPPLY

FIGURE 5-15 DELETED

5.2.6.1 HIGH-VOLTAGE POWER SUPPLY

The primary ac input voltage is transformed to approximately 220-volts ac by transformer T901 located on the main chassis. This ac voltage is then full-wave rectified by diodes CR801 through CR804, and filtered by capacitor C901 on the main chassis. The resulting 330-volts dc is applied to the gas-discharge noise generator anode connector through R902, R903, R904, and CR703. R902 is used to set the desired noise generator current during operation. R903 and R904 are current limiting resistors.

5.2.6.2 MODULATOR

The modulator consists of transistors Q801, Q802, and Q803. When the noise generator is pulsed on, transistor Q801 receives a synchronous negative pulse. When Q801 turns off, Q802 and Q803 are provided with a positive voltage at their bases, thereby causing these transistors to switch on, completing the noise generator cathode circuit. To turn the noise generator off, a positive pulse is applied to Q801 causing this stage to saturate, grounding the bases of Q802 and Q803. This turns these transistors off which in turn causes the noise generator to extinguish. During the automatic mode, this operation continues at a 400-Hz rate. During manual operation, once the noise generator is turned on, no further pulsing action is required. Therefore, when the noise generator is on its current returns to ground through R808 which develops a voltage sufficient to saturate Q804. Saturation of Q804 reduces E809 to approximately zero volts and prevents any further high voltage ignition pulses. Resistor R807 samples the noise generator current, and in conjunction with R806, provides an indication of the current on the meter when the scale selector is in NOISE GENERATOR position.

5.2.6.3 thru 5.2.6.4 (Deleted)

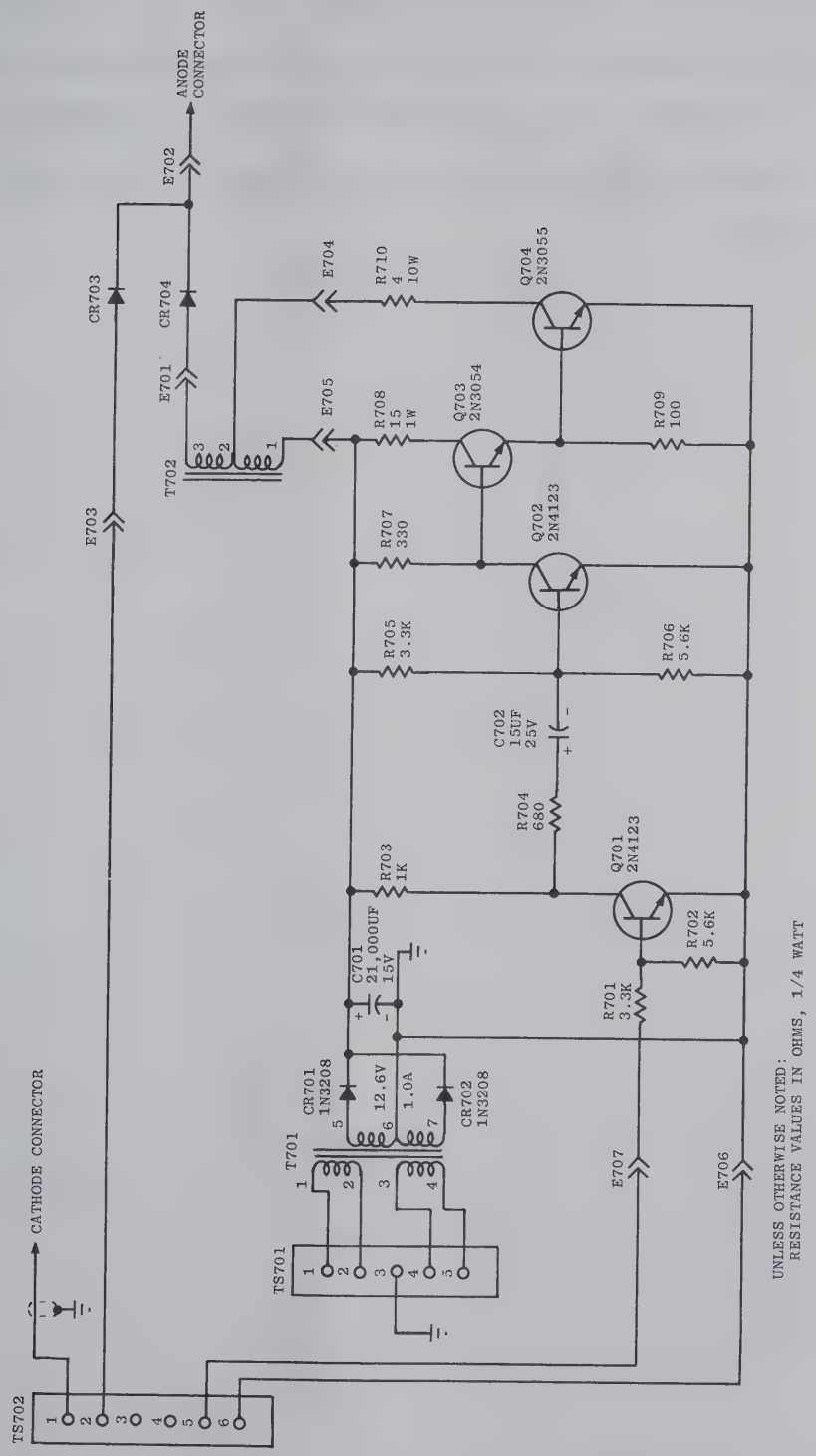
5.2.7 IGNITION MODULE (P/N 213000)

As described in paragraph 5.2.6, the ignition module is used in conjunction with the gas noise generator power supply. The two units are built separately so as to permit remote operation of the noise generator (up to 1000 feet). (Refer to schematic Figure 5-16.) The ac primary power is converted to approximately +10 volts by T701, CR701, CR702, and C701. During the automatic and manual-on mode of operation, the output of the multivibrator (E603) is applied to pin 5 of TS702, through CR901 and R923. When this square wave is positive (approximately +9 volts), the pulse, coupled through CR901, turns Q701 on causing its collector voltage to drop to approximately zero. This, in turn, causes Q702 to turn off and its collector voltage rises turning on transistors Q703 and Q704. When Q704 is on, it draws approximately 3 A through T702 primary. The multivibrator output now goes negative and diode CR901 opens, causing the action previously described to reverse, which in turn causes Q704 to open, thus rapidly turning off the current in the transformer primary. The collapsing magnetic field, coupled with a high turns ratio on T702, produces a voltage spike of, typically, 4 kV. This is coupled to the anode connector, and is used to break down the plasma in the gas-discharge noise generator. CR703 decouples these high voltage pulses from the main dc power supply. During the manual-on mode, the operation of this circuit is the same as described, until the noise generator ignites. This ignition causes transistor Q804 (on the gas noise generator power supply) to saturate, which in turn grounds pin 5 of TS702, thus preventing any further ignition pulses.

5.2.8 FREQUENCY CONVERTER (P/N 07530)

The frequency converter is designed to be installed into the PANFI so that the instrument can accept input frequencies in the range of 40 to 150 MHz.

The input section consists of a double balanced mixer and a local oscillator. The local oscillator is tunable by means of a shaft extending through the front panel of the Type 75. The local oscillator operates from 70 to 120 MHz. (Refer to schematic Figure 5-17.)



T66ZX001-017

FIGURE 5-16. SCHEMATIC DIAGRAM OF IGNITION MODULE

The output of the mixer is internally connected to the second section. This section is made up of a filter and a 30 MHz amplifier. The filter is a five section bandpass filter centered at 30 MHz and is designed to provide a minimum of 50 dB rejection at 70 MHz. The gain of the amplifier is adjusted so that the overall gain of the filter-amplifier and converter assembly is unity. (Refer to schematic Figure 5-19.)

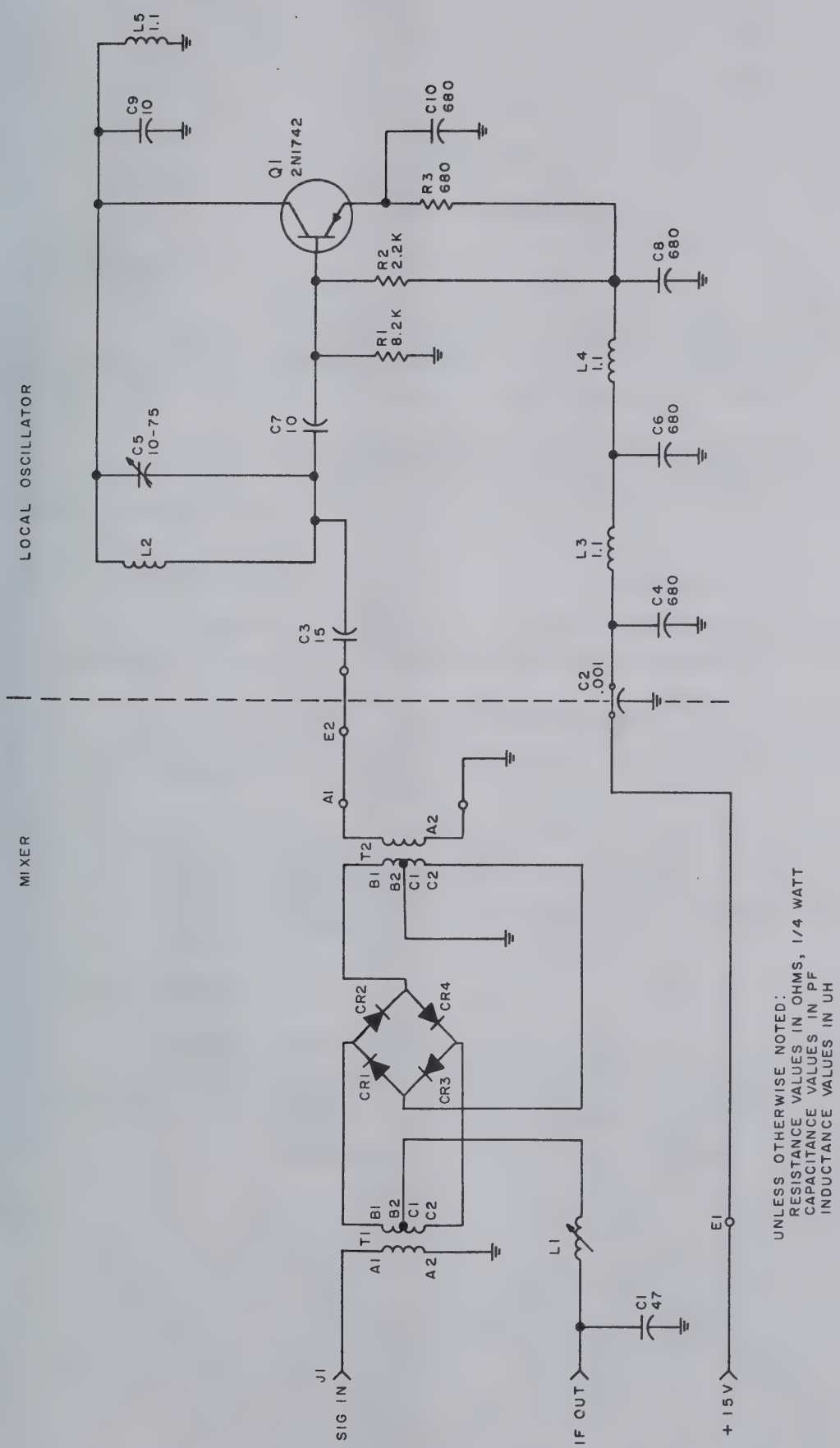


FIGURE 5-17. SCHEMATIC DIAGRAM OF FREQUENCY CONVERTER

FIGURE 5-18 DELETED

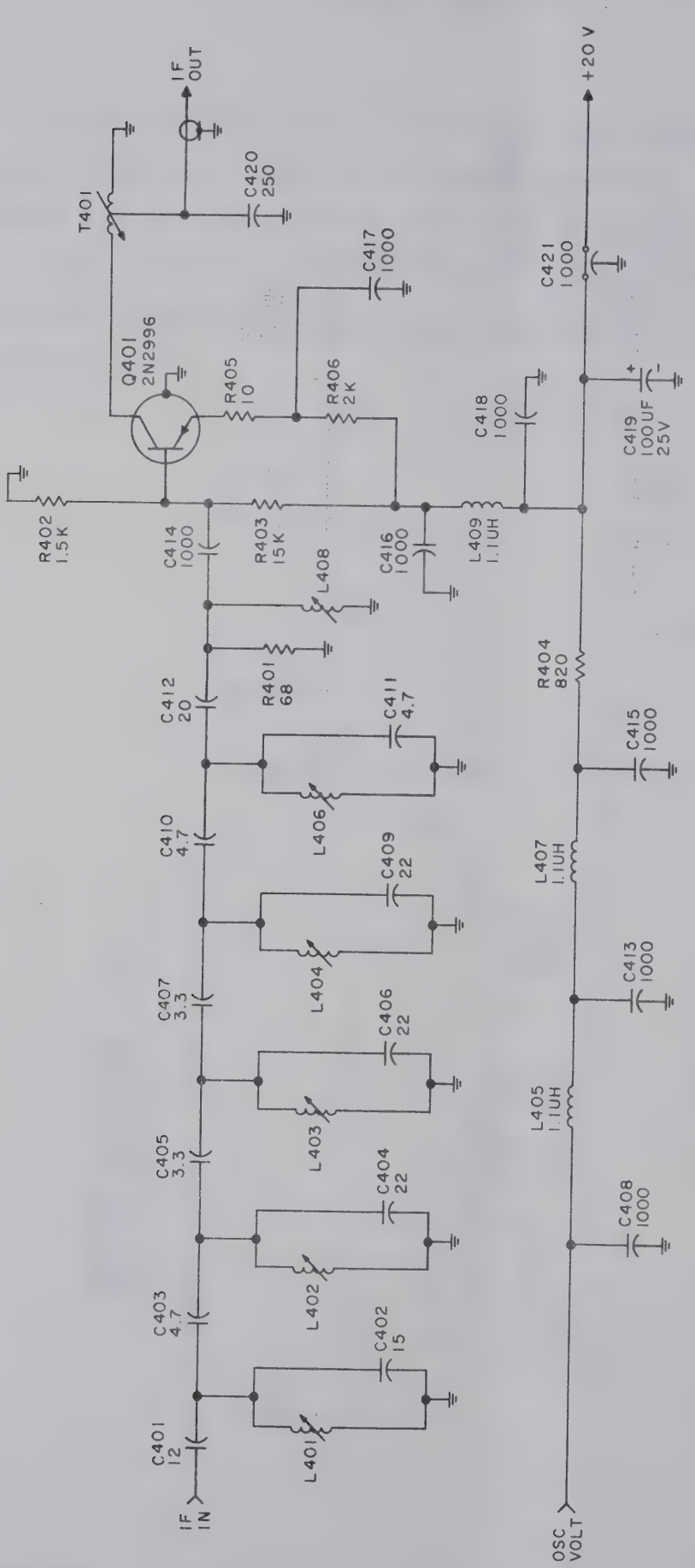


FIGURE 5-19. SCHEMATIC DIAGRAM OF FILTER-AMPLIFIER

FIGURE 5-20 DELETED

PAGES 5-35 THRU 5-36 DELETED

SECTION VI

MAINTENANCE

6.1 GENERAL

The use of solid-state components for all active elements, and the selection of high quality components, assures a long trouble-free life for the type 75 Precision Automatic Noise Figure Indicator.

Information to aid in the isolation of a trouble is provided below. Figure 6-1 shows a top view of the Type 75 PANFI; Figure 6-2 shows a bottom view.

6.2 FACTORY REPAIR

If it becomes necessary to return the unit or a component to the manufacturer for repairs, the following instructions should be followed:

- Write to the AIL Microwave Instruments Sales Department giving complete information concerning the failure. Include the unit type and serial number.

- Special shipping instructions will be supplied by AIL. Pack and ship the equipment as directed. Transportation charges should be prepaid and a failure report should be supplied with the equipment.

6.3 MAINTENANCE

The Type 75 PANFI has been designed for minimum maintenance and has few internal adjustments (refer to schematic Figure 6-3). There is only one internal adjustment necessary to insure that the Type 75 is fully

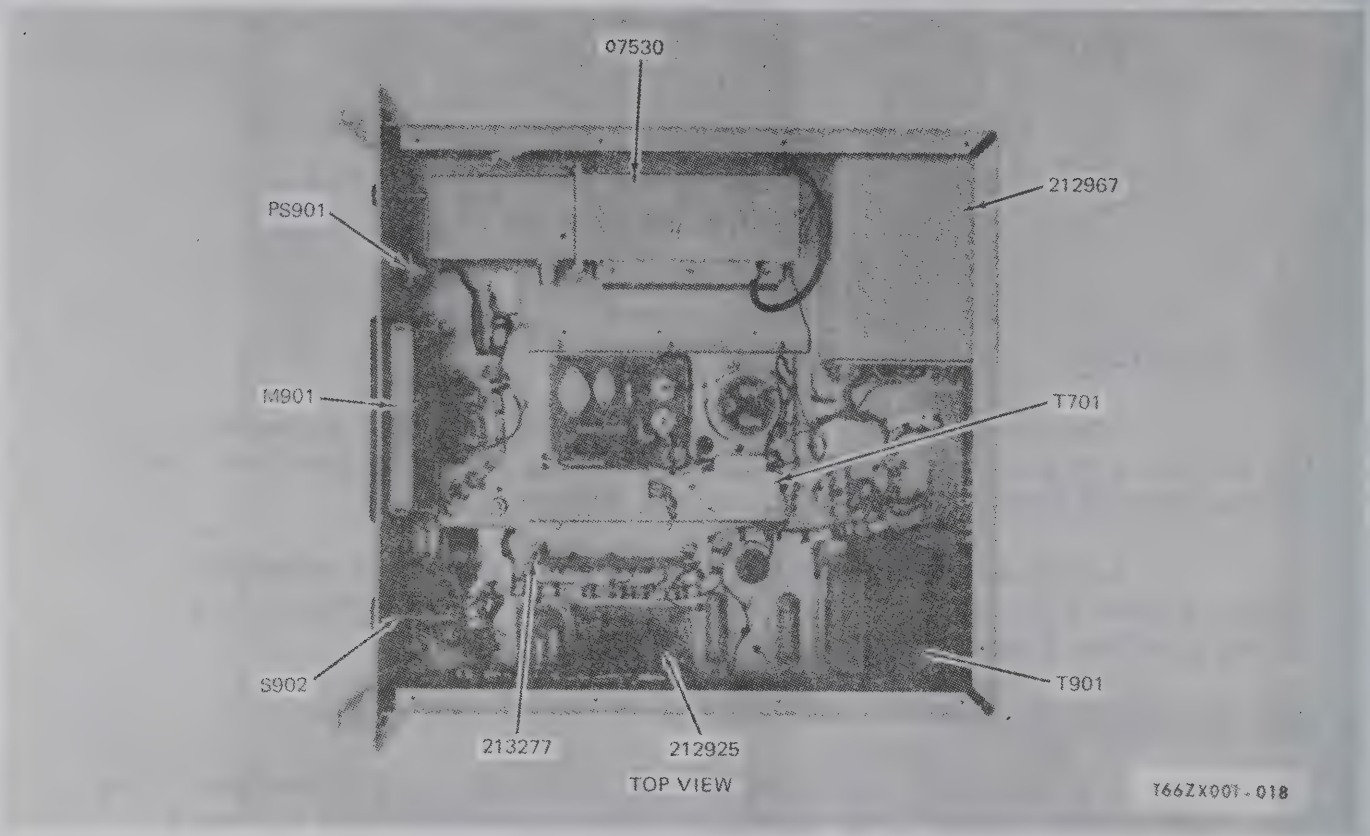


FIGURE 6-1. TYPE 75 PANF1 TOP VIEW

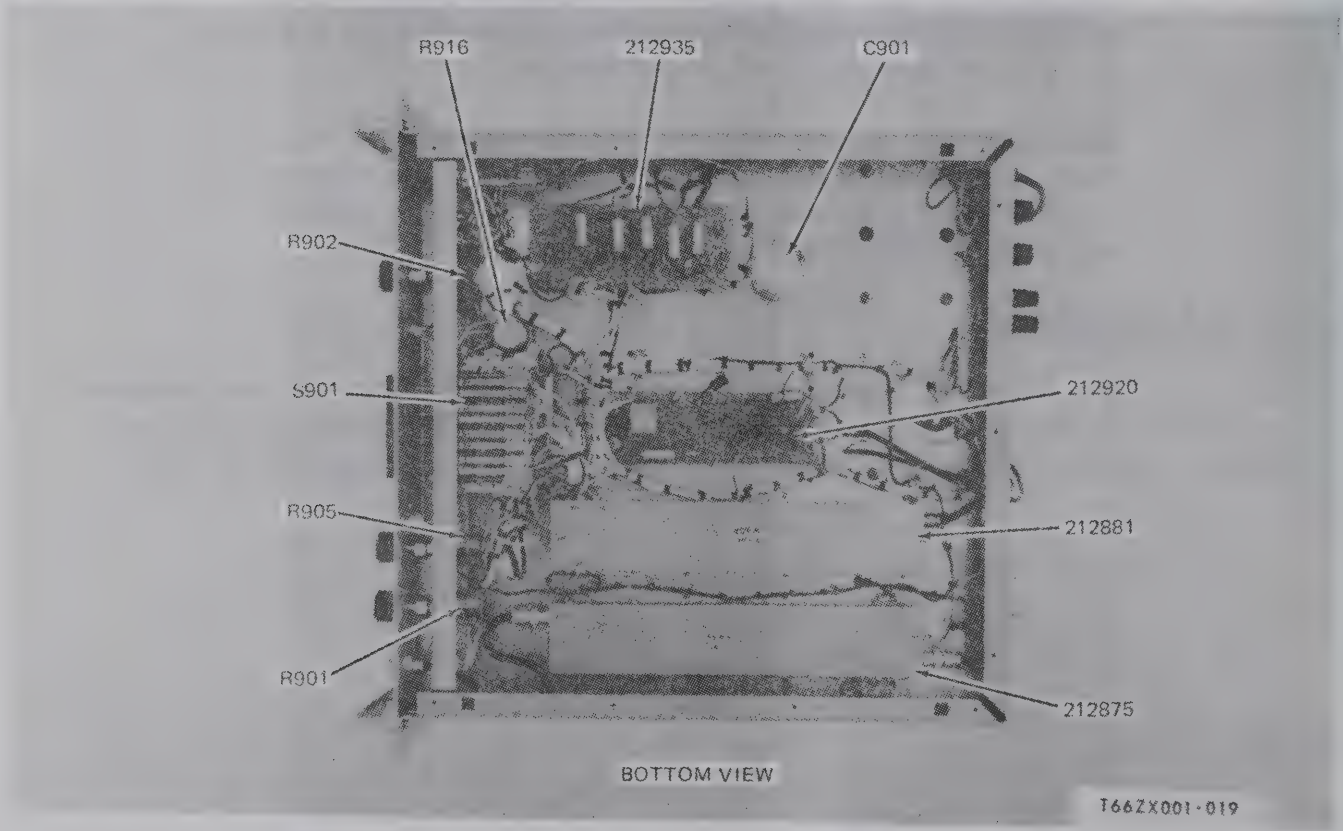
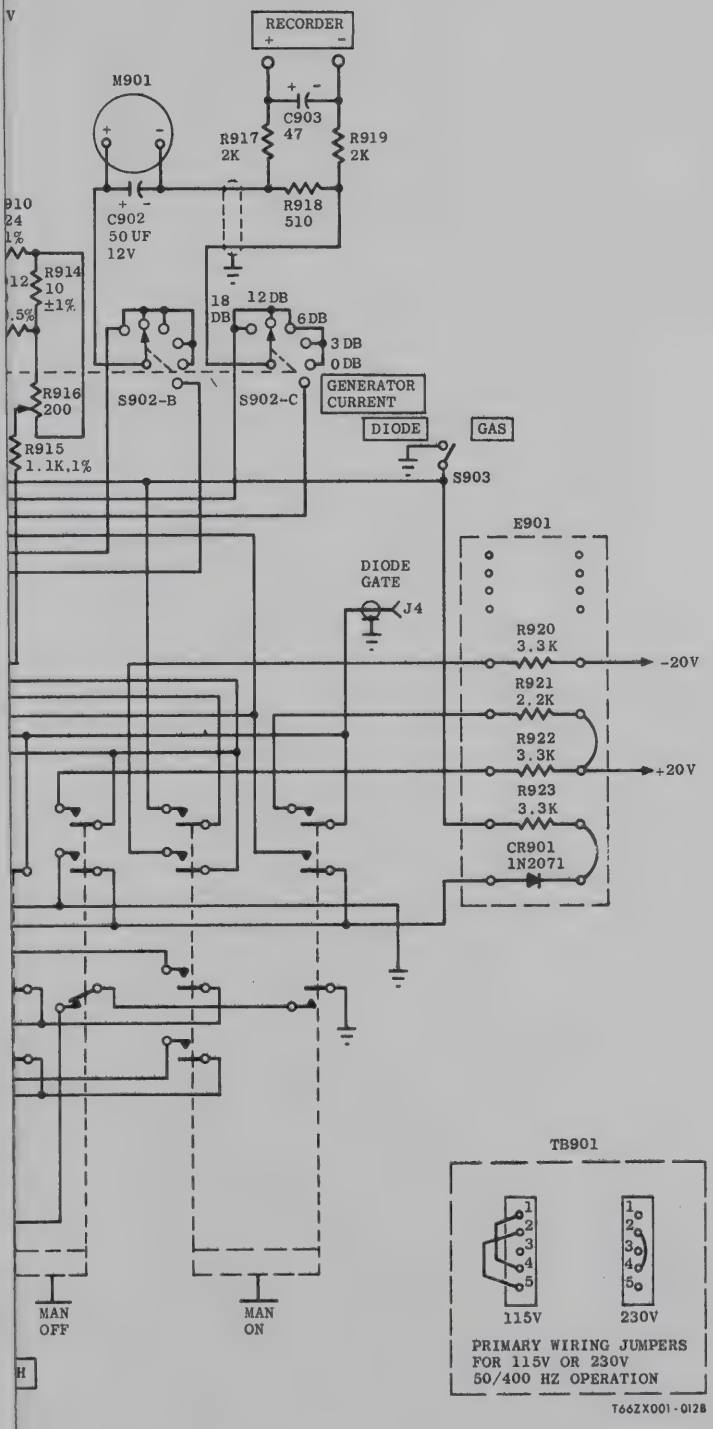


FIGURE 6-2. TYPE 75 PANF1 BOTTOM VIEW



TIC DIAGRAM OF PANEL

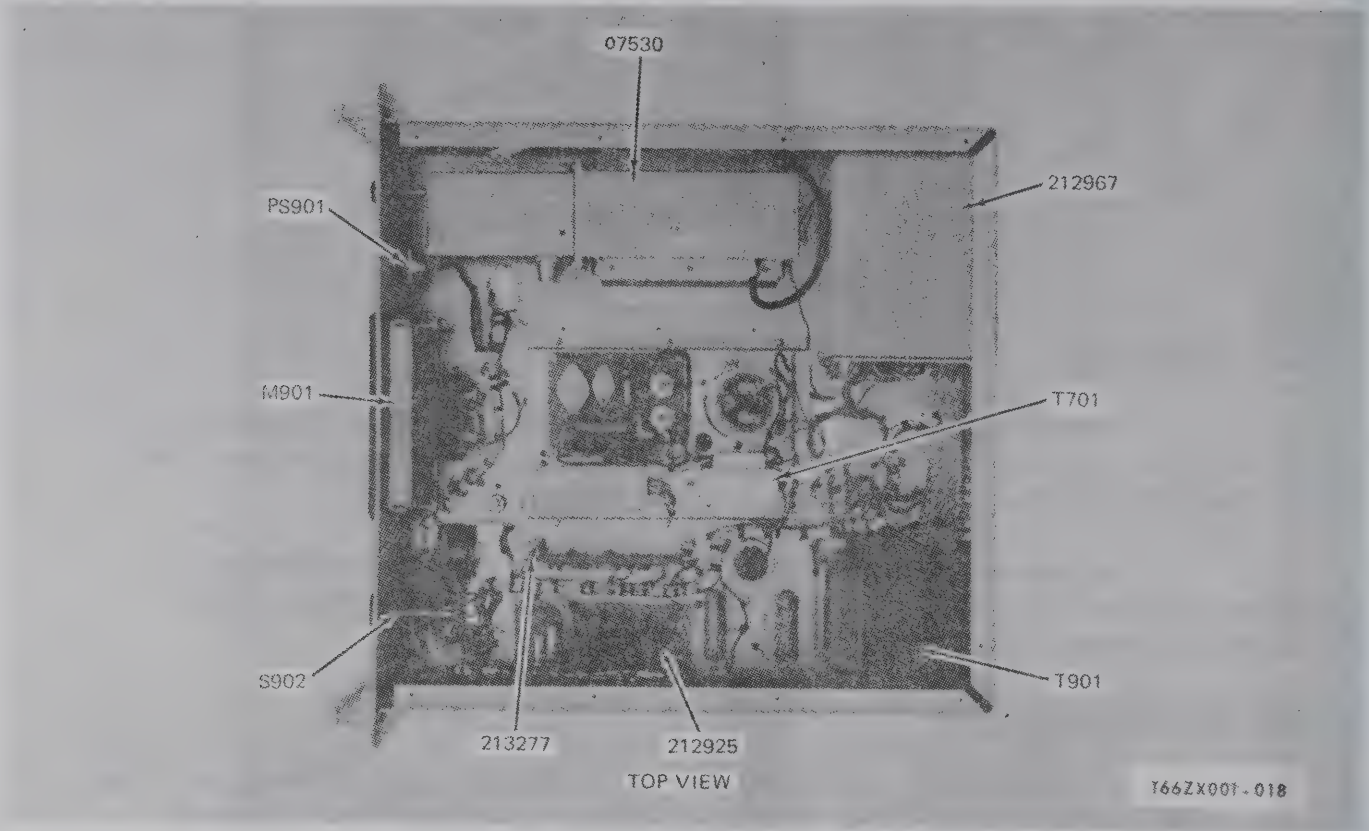


FIGURE 6-1. TYPE 75 PANF1 TOP VIEW

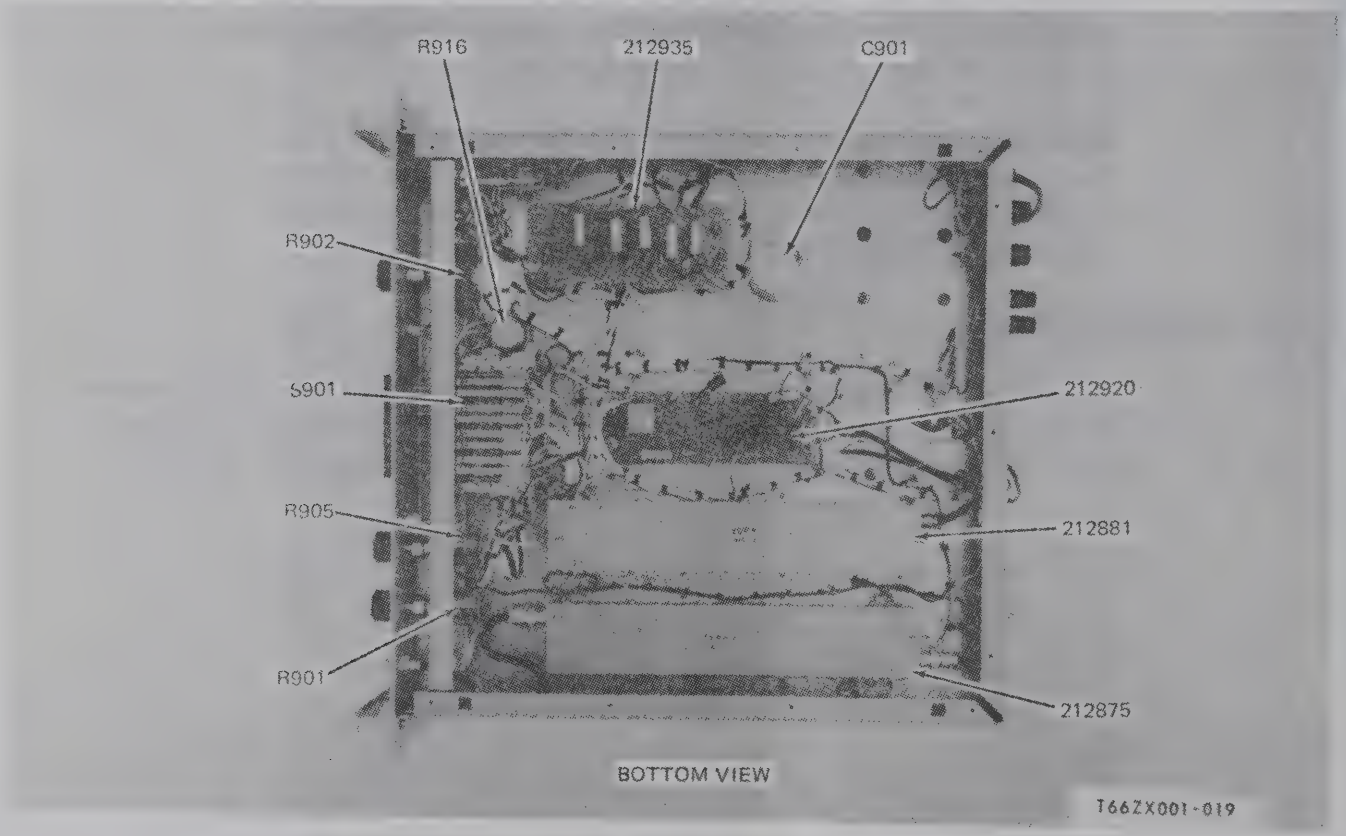
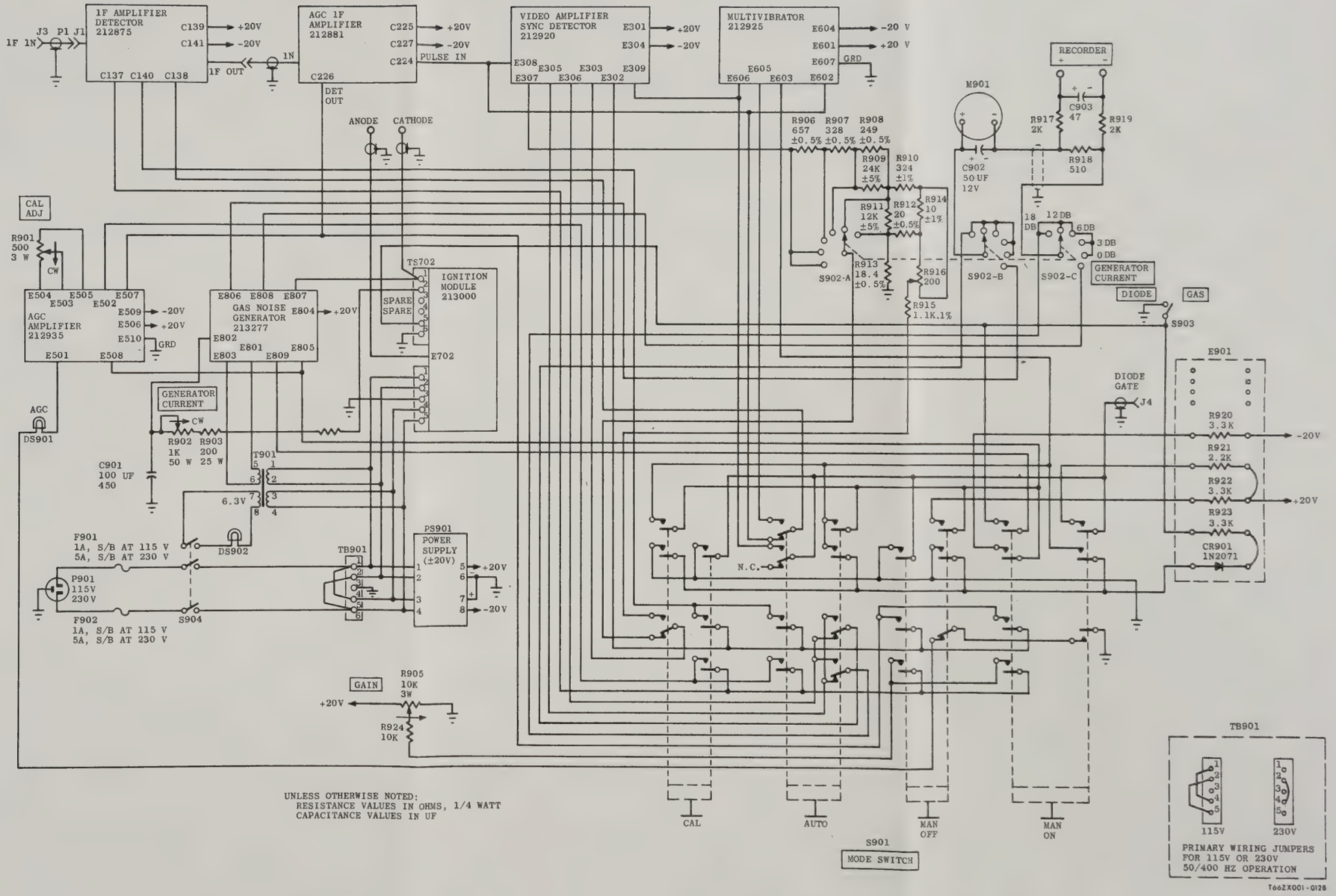


FIGURE 6-2. TYPE 75 PANF1 BOTTOM VIEW



UNLESS OTHERWISE NOTED:
RESISTANCE VALUES IN OHMS, 1/4 WATT
CAPACITANCE VALUES IN UF

FIGURE 6-3. SCHEMATIC DIAGRAM OF PANEL

calibrated and operational. This adjustment correlates the automatic reading to the CAL ADJ control on the calibrate scale. This can be checked very simply at any time during the operation. The procedure is as follows:

1. Using an AIL Type 32 Precision Attenuator, carefully make a manual noise figure measurement (see Section IV).
2. Switch over to the CAL mode and set the CAL ADJ control for the correct excess noise ratio.
3. Switch to AUTO and note the automatic noise figure reading. This should be done for one noise figure reading on each scale of the meter.
4. Compare the results with the manual readings. When the PANFI is out of adjustment, the automatic readings will differ from the manual readings in the same direction by approximately the same amount (that is, difference = -0.3 dB).
5. Correct the meter by adjusting the CAL ADJ control in the AUTO mode such that the automatic and manual readings agree.
6. Depress the CAL mode button and adjust R916 to return the calibrate reading on meter to that value previously set. The Type 75 PANFI is now ready for operation.

6.4 TROUBLESHOOTING

6.4.1 POWER SUPPLIES

6.4.1.1 GENERAL

The Type 75 PANFI is powered by three solid-state power supplies operating from the primary ac power through the two fuses (F_1 and F_2). If fuses F_1 and F_2 are blown, the fault can be located by disconnecting all three power supplies from the primary power line. Reconnect the power supplies one at a time to determine the faulty unit.

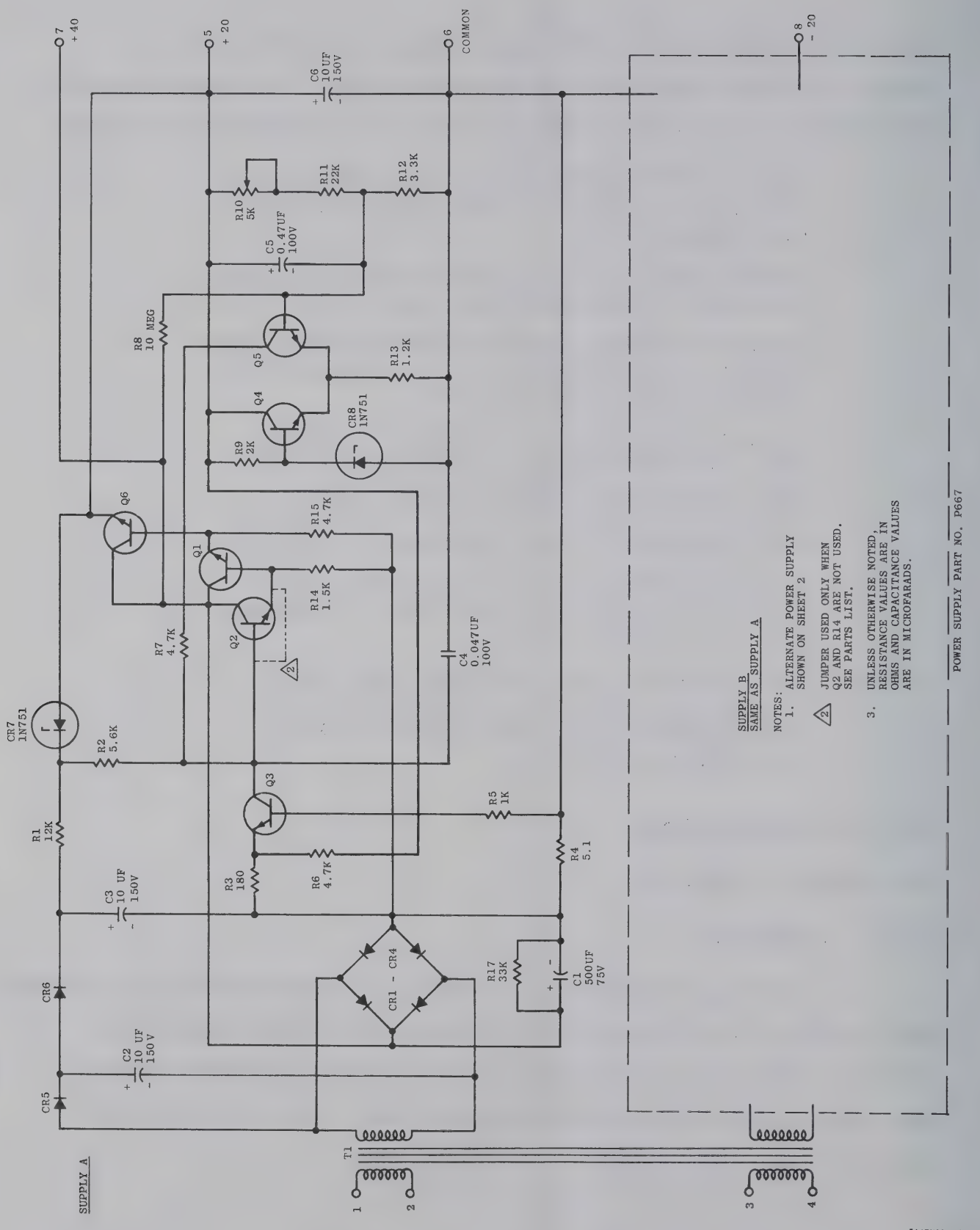
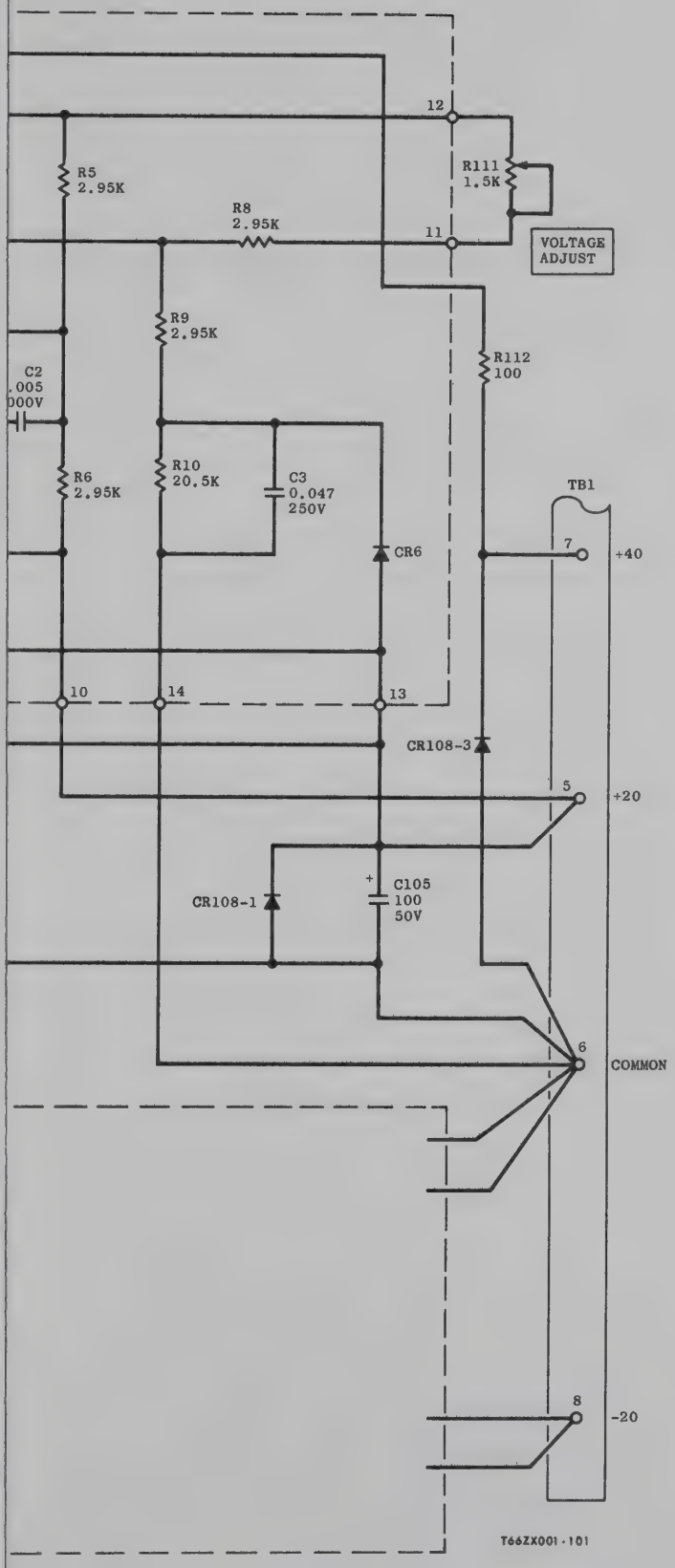


FIGURE 6-4. SCHEMATIC DIAGRAM OF MODULAR ±20V POWER SUPPLY (SHEET 1)



MODULAR ±20V POWER SUPPLY (SHEET 2)

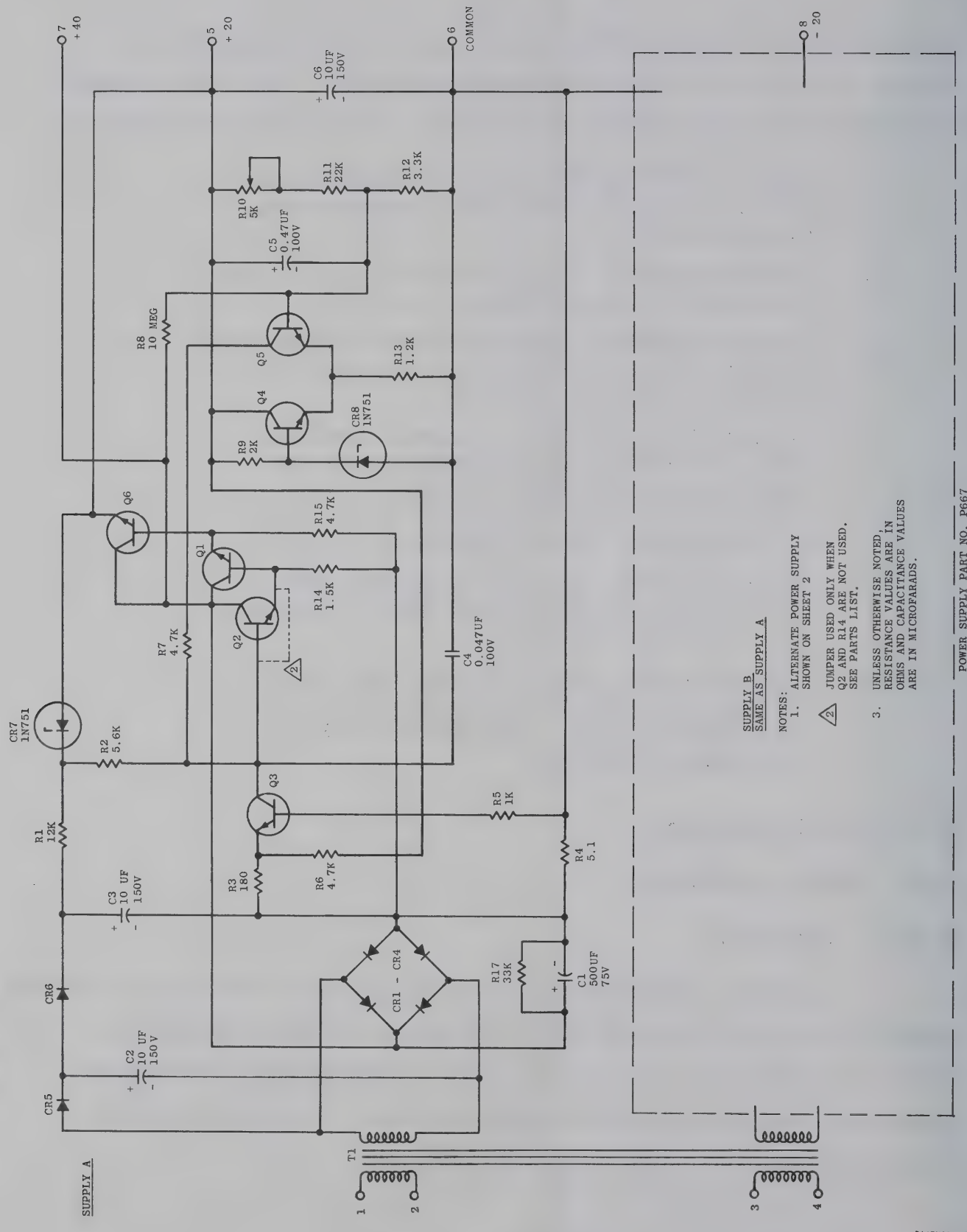
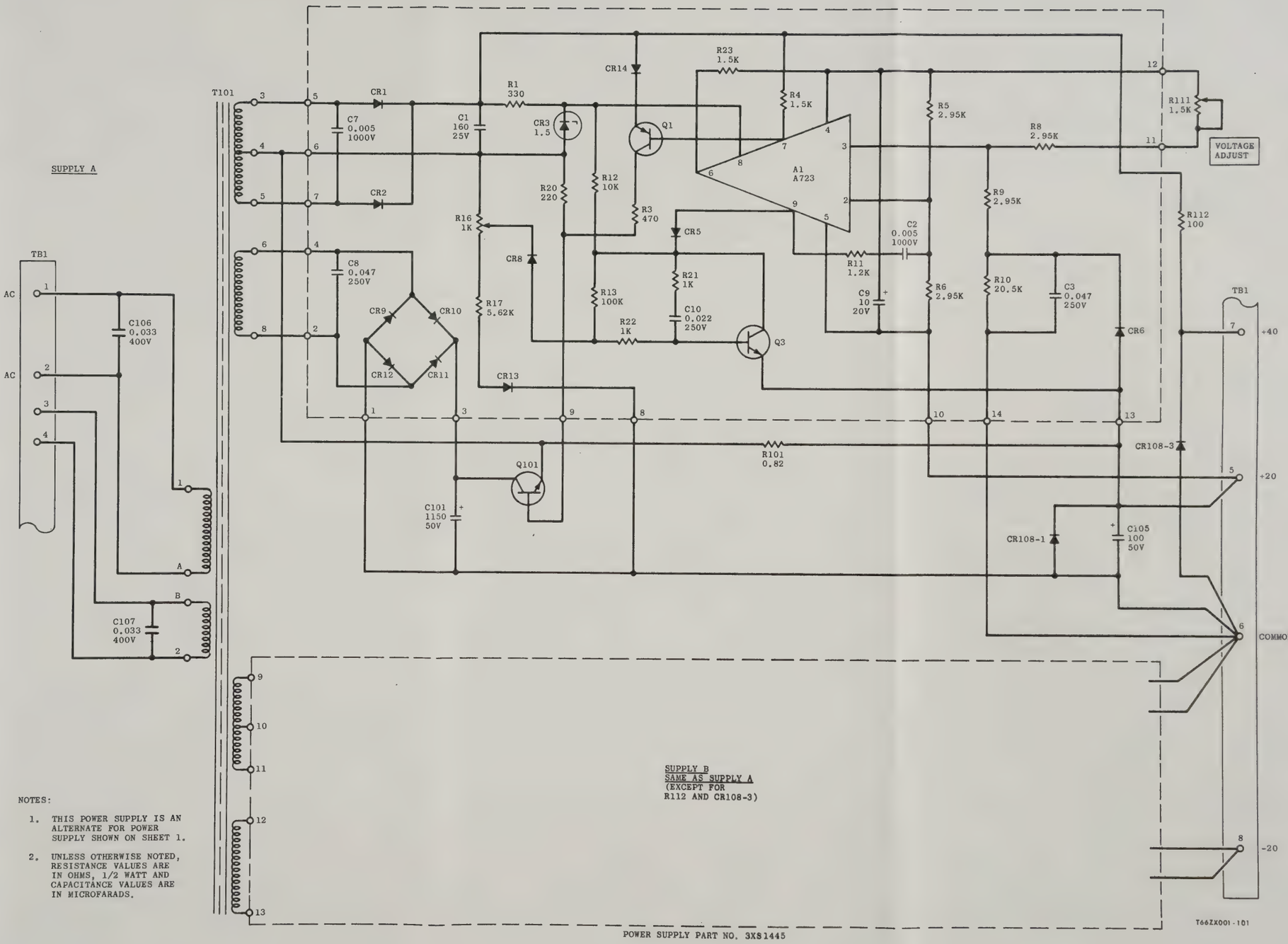


FIGURE 6-4. SCHEMATIC DIAGRAM OF MODULAR ±20V POWER SUPPLY (SHEET 1)



NOTES:

1. THIS POWER SUPPLY IS AN ALTERNATE FOR POWER SUPPLY SHOWN ON SHEET 1.
2. UNLESS OTHERWISE NOTED, RESISTANCE VALUES ARE IN OHMS, 1/2 WATT AND CAPACITANCE VALUES ARE IN MICROFARADS.

FIGURE 6-4. SCHEMATIC DIAGRAM OF MODULAR ±20V POWER SUPPLY (SHEET 2)

6.4.1.2 MODULATOR 20 V POWER SUPPLY (P/N 212967)

This power supply provides an electronically regulated +20 and -20 volts to all submodules in the Type 75. Primary ac input power and dc output power are provided on one terminal strip. The dc voltages are adjustable by ±10 percent, around 20 volts, by two controls which are located on the power supply. (Refer to schematic Figure 6-4.)

6.4.1.3 +300 VOLT DC POWER SUPPLY

This power supply provides the sustaining voltage for the gas-discharge noise generators. Since this is an unregulated power supply, the output voltage will be a function of the load. To check this power supply, perform the procedures listed in the following steps.

1. Press the MANUAL OFF button and check for approximately +350 V dc at E802.
2. If no voltage (or low voltage) is present, check the ac voltage between E801 and E803. This should be about 250 V ac.
3. With a gas-discharge noise generator connected and drawing about 200 mA in the MANUAL ON mode, the voltage at E802 should drop to about 295 V dc. If the voltage is very low when the MANUAL ON button is depressed, check the current on the front panel meter. If it is unstable, or very low, replace the noise generator.
4. If the voltage is low regardless of which mode button is depressed, check the condition of the four bridge-rectifier diodes (CR101 through CR104) for an open circuit.

6.4.1.4 IGNITION MODULE POWER SUPPLY

The third power supply, located on the ignition module, is used to power the transistors on this module, and generate the ignition pulse through T702. Failure of this power supply will result in the gas-discharge noise generator not being ignited. The output voltage of this power supply should be about +9 volts during all modes of operation except automatic, at which time it drops to +7.5 volts. The primary ac voltage is stepped down in a 12-volt center-tapped secondary, and applied to CR701 and CR702 which form a full-wave rectifier when connected to the center-tapped transformer.

6.4.2 IF AMPLIFIER CIRCUITS

Two IF amplifier circuits are used--a tuned IF amplifier in the IF amplifier-detector module and a feedback amplifier in the AGC IF-amplifier module.

During the manual modes of operation, the two amplifiers are cascaded, and the signal flows through both amplifiers before being processed for display on the meter.

During the automatic and the calibrate modes, the signal which is displayed on the meter flows only through the tuned IF-amplifier before being processed for display. In the meantime, the feedback IF amplifier, in the AGC IF amplifier-detector module, takes the output signal from the tuned IF, amplifies it, and applies it to the processing circuits which ultimately generate a dc signal for the gain control circuits in the tuned IF amplifier.

Failure of either amplifier will cause a failure in all modes of operation. To determine which amplifier has failed, switch to the manual mode and insert a 30-MHz CW signal into the IF input. Examine the outputs of each of the square-law detectors.

CAUTION

The output of the detector in the AGC IF amplifier-detector module is dc-coupled and a short-to-ground at this point will damage this unit.

If no output appears from either detector, the tuned IF amplifier should be checked (using Table 6-1). If an output appears from the IF amplifier-detector output, but none from the AGC IF amplifier-detector output, the feedback amplifier should be checked (using Table 6-2).

TABLE 6-1. IF AMPLIFIER-DETECTOR VOLTAGES (P/N 212875)

Test Point	Voltage (in volts)
Emitter Q101	+4.2
Base Q101	+3.5
Emitter Q102	+4.1
Base Q102	+3.4
Emitter Q103	+6.0
Base Q103	+6.3
Emitter Q104	+5.7
Base Q104	+6.0
C139	+20.0
Junction L108 and R123	+10.0
Base Q105	0.0
Emitter Q105	-0.7
Base Q106	-4.6
Emitter Q106	-4.8
Collector Q106	-0.9
Collector Q107	+6.4
Base Q107	0.0
Emitter Q107	-0.7
Collector Q108	+20.0
Emitter Q108	+6.0
Junction R138 and C135	-9.6

NOTE

All voltages listed in the tables are ±20 percent, measured with a 20,000 ohm/volt dc meter (referenced to ground).

TABLE 6-2. AGC IF AMPLIFIER (P/N 212881)

Test Point	Voltage (in volts)
Base Q210	+11.2
Collector Q201	+0.67
Emitter Q201	+11.7
Junction R206 and R205	+19.0
Emitter Q202	0
Collector Q202	+6.3
Emitter Q203	+6.6
C225	+20.0
Q204B	0
Q204C	+20.0
Q204E	-0.6
Q205C	-0.8
Q205B	-4.6
Q205E	-4.8
Junction R223 and R224	-9.6
Q206E	-0.6
Q206B	0
Q206C	+6.5
Q207C	+20.0
Q207E	+6.0

NOTE

All voltages listed in the tables are ±20 percent, measured with a 20,000 ohm/volt dc meter (referenced to ground).

6.4.3 DIODE SWITCHES

Two diode switches are used in the Type 75 PANFI--one between the tuned IF amplifier and its square-law detector (for this discussion this will be called switch A); the other (switch B) between the feedback amplifier and its square-law detector in the AGC IF amplifier module.

Switch B is operated by a 400-Hz square wave, derived from the astable multivibrator, during all modes of operation. Switch A is driven by the same signal during the calibrate and manual modes. During the automatic mode, switch A is operated by a 200-μsec pulse, derived from the monostable multivibrator.

Failure of switch A will show up as a lack of meter deflection in the CAL mode. Failure of switch B will prevent the AGC light from going on in either the automatic or CAL mode.

6.4.4 SQUARE-LAW DETECTORS

Two square-law detectors are used in the Type 75 PANFI--one in the IF amplifier-detector module (detector A), and one in the AGC IF amplifier-detector module (detector B).

The output from detector A is not used in the manual modes of operation. It is fed to the video amplifier in the automatic and calibrate modes. The output from detector B is fed to the video amplifier in the manual mode. In the automatic and calibrate modes its output is fed to the AGC amplifier. At all times it is dc-coupled to the AGC amplifier.

CAUTION

Do not short this output, as this will result in damage to the square-law detector.

Failure of detector A will be indicated by no front panel meter reading in the automatic or calibrate modes. Its failure will have no effect on the manual mode.

Failure of detector B will show up as an inability to obtain a meter reading in the manual mode of operation and will prevent the AGC indicator from lighting in the automatic or calibrate mode. The dc voltages for these detectors are given in Tables 6-1 and 6-2.

6.4.5 VIDEO AMPLIFIER-SYNCHRONOUS DETECTOR

The video amplifier-synchronous detector module is used to amplify the two different noise levels appearing at its input, and to display the difference on the front panel meter. The front panel switch (SCALE SELECTOR) is used to change the gain of the video amplifier and, therefore, change meter scales. Failure of this switch will result in the inability to change the meter reading (in the automatic or manual modes). In the calibrate mode, this switch is disabled. Failure of either the video amplifier or the synchronous detector will result in no meter detection in any mode of operation. This can be isolated by noting that there is an output from both square-law detectors in all modes of operation. The dc operating voltages are given in Table 6-3. (Note that the voltages of several transistor bases or emitters are not given). This is due to the fact that a meter placed in these circuits may cause the stage to oscillate. This is indicated by observing the meter reading, which will change when the stage oscillates.

6.4.6 AGC AMPLIFIER

This module amplifies the output of square-law detector B and generates a proportional dc voltage. It also lights the AGC indicator when the input level is above a preset reference level. Failure of this mode will result in a large error in the automatic noise figure, or the calibrate

TABLE 6-3. VIDEO AMPLIFIER-SYNCHRONOUS DETECTOR (P/N 212920)

Test Point	Voltage (in volts) (Scale Selector Set to 0 dB)
Q301C	+8.3
Q301E	0
Q301B	+0.6
Q302E	-6.2
Q302B	-5.6
Q303E	+20.0
Q303B	+19.4
Q303C	+0.75
Q304C	+19.4
Q304E	+0.1
Q305E	+20.0
Q305C	+2.30
Q306B	+1.7
Q307B	+1.4
Q307E	+1.3
Q307C	-10.0
E304	-20.0

NOTE

These readings are taken with meter reading at full scale.

level, as displayed on the front panel meter in the automatic or calibrate modes, respectively. It will also show up as a failure to light the AGC light on the front panel. Table 6-4 lists the DC voltages for this module.

6.4.7 MULTIVIBRATOR

The multivibrator acts as the basic timing generator in the Type 75 PANFI. Failure of the astable multivibrator causes a failure of the Type 75 PANFI in all modes of operation. In addition, the noise generator will not operate. Failure of the monostable multivibrator will show up as an error in the automatic noise figure reading, when compared to the manual noise figure. This is due to the fact that diode switch A does not eliminate the first 200 μsec of the noise pulse and the Type 75 then becomes sensitive to the various turn-on times of the noise generators. The DC operating voltages for this module are given in Table 6-5.

6.4.8 GAS NOISE GENERATOR POWER SUPPLY AND IGNITION MODULE

These two subunits are grouped together because one will not work without the other. The ignition module generates the pulse necessary to ignite the gas-discharge noise generator (typically 4 kV) when the GAS-DIODE switch is in the GAS position. The gas noise generator power supply sustains the noise generator, and contains the modulator circuits used during the automatic mode of operation. Failure of the ignition module will be indicated by the absence of the ignition pulse. This pulse may be viewed, using a high-voltage probe and an oscilloscope, on pin 3 of T702. Pin 3 is easily identified by the high-voltage insulator. Table 6-6 gives the DC voltage for this module.

Failure of the gas noise generator power supply will prevent the gas noise generator from being sustained (failure in the +300 V supply) or will result in the inability to either modulate or turn off the noise generator without disconnecting the anode or cathode lead (failure of Q801, Q802, Q803, or Q804). Table 6-7 gives the DC voltages for this module.

TABLE 6-4. AGC AMPLIFIER (P/N 212935)

Test Point	Voltage (in volts) No Input to Type 75; CAL Button Depressed; AGC Light OFF	Voltage (in volts) -60 dBm Input to Type 75; AUTO Button Depressed; AGC Light ON
E507 (Q509B)	+6.4	+6.4
Q509C	+20.0	+20.0
Q509E	+5.8	+5.8
Junction R22 and R516	-11.4	-10.8
Junction R518 and C508	0	+0.2
Q507B	0	+0.2
Q507C	+16.0	+10.4
Q507E	-0.4	-0.35
Junction R517 and R515	+1.8	+18.0
Q506C	+5.6	+10.8
Q506B	+0.2	+0.2
E503	+0.25	+0.2
E504	+0.2	+0.2
E505	+0.55	+0.65
Junction R511 and R509	+9.0	+9.0
Junction R509 and L501	+20.0	+20.0
Q505C	+20.0	+18.5
Q505E	+9.4	+11.5
Q504C	-12.0	+1.6
Q503E	-10.0	+1.0
Q502B	-9.4	-0.15
Q502E	-1.2	-0.7
Q502C	+20.0	-0.7
Q501B	+20.0	+19.0
Q501E	+20.0	+20.0
Q501C	0	+20.0

TABLE 6-5. MULTIVIBRATOR (P/N 212925)

Test Point	Voltage (in volts)
Junction R610 and C605	+10.0
Q605C	-1.3
Q605B	-11.2
Q605E	-9.0
Q604C	-0.7
Q603E	-0.25
E604	-20.0
Q602C	+3.5
Q602B	+8.3
Q602E	+8.4
Q601B	+12.0
Q601C	-12.0
Q606C	-1.25
Q606B	-11.2
Q606E	-9.0
Q607C	-0.4
Q607E	-9.6

TABLE 6-6. GAS NOISE GENERATOR POWER SUPPLY (P/N 213277)

Test Point	Voltage (in volts) (MANUAL-ON) (Note 1)	Voltage (in volts) (MANUAL-OFF) (Note 2)	Voltage (in volts) (AUTO) (Note 3)
E801 to E803	240 ac	250 ac	240 ac
E802	+297.0	+340.0	+300.0
Junction R903 and R902	+208.0	+340.0	+265.0
Junction 904 and TS702-2	+140.0	+340.0	+230.0
E805	-11.0	+11.0	-0.25
Q801B	-0.50	+0.75	+0.2
Q801C	+17.0	-0.10	+1.8
Q803E	+1.95	0	+1.0
E808	+2.05	0	+140.0
E807	+2.75	0	+140.0
Q804B	+0.75	0	+0.75
Q804C	0	0	0

Notes:

1. Gas noise generator connected (07012), operating at 175 mA.
2. Gas noise generator connected (07012), no current.
3. Gas noise generator connected (07012), current set at 175 mA in MAN-ON mode.

TABLE 6-7. IGNITION MODULE (P/N 213000)

Test Point	Voltage (in volts) (MANUAL-ON) (Note 1)	Voltage (in volts) (MANUAL-OFF) (Note 2)	Voltage (in volts) (AUTO) (Note 3)
E705*	+9.4	+9.4	+7.8
E707*	0	0	+1.8
Q701B	0	0	+0.35
Q701C	+9.4	+9.4	+2.5
Q701E	0	0	0
Q702B	+0.75	+0.75	+0.25
Q703B	+0.2	+0.2	+1.0
Q703E	0	0	+0.5
Q704C	+9.4	+9.4	+6.0
Q704E	0	0	0
E704	+9.4	+9.4	+7.0

CAUTION

Voltages in excess of 4 kV may be present on E705 and E707.*

Notes:

1. Gas noise generator connected (07012), operating at 175 mA.
2. Gas noise generator connected (07012), no current.
3. Gas noise generator connected (07012), current set to 175 mA in MAN-ON mode.

SECTION VII

PARTS LIST

7-1. INTRODUCTION.

7-2. This section contains information for ordering replacement parts for the Type 75 Precision Automatic Noise Figure Indicator manufactured by Airborne Instruments Laboratory (AIL), Deer Park, Long Island, New York. Parts are listed in order by reference designation. The parts list provides the following information on each part:

a. Reference designation (Item column).

b. Complete description (Name column).

c. Manufacturer.

d. Manufacturer's part number.

7-3. ABBREVIATIONS.

7-4. All symbols and abbreviations used in the parts list are in accordance with Military Standard MIL-STD-12, Abbreviations for Use on Drawings and in Technical-Type Publications except as noted below:

pF	picofarad = 10^{-12} farad
Ω	ohms
%	percent

REPLACEABLE PARTS LIST

Item	Name	Manufacturer	PART NO.
	MAIN CHASSIS		
C901	Capacitor, electrolytic, 100 μ F, 450 v	Sprague	TVC1750
C902	Capacitor, electrolytic, 50 μ F, 12 v	Sprague	TE1100
C903	Capacitor, electrolytic, 47 μ F, 35 v	-	CS13BFG476K
CR901	Diode	-	1N2071
DS901	Lamp, 6 v	Chicago Miniature	CM370
DS902	Lamp, 18 v	Chicago Miniature	CM381
F901, 902	Fuse, Slo Blo, 1A	Littlefuse	313001
J3	Jack, bulkhead, BNC	-	UG909/U
J4	Receptacle, BNC	-	UG625B/U
M901	Meter	AIL	212827
P1	Plug, BNC	-	UG88B/U
P901	Plug assembly	AIL	990050
R901	Potentiometer, 500 ohms, 3 w, 10 turn	Spectrol	530

Item	Name	Manufacturer	Part No.
R902	Potentiometer, 1 k, 50 w	Ohmite	0326
R903	Resistor, fixed, 200 ohms, 25 w	Ward Leonard	25F200
R904	Resistor, fixed, 250 ohms, 25 w	Ward Leonard	25F250
R905	Potentiometer, 10 k, 3 w, 10 turn	Spectrol	530
R906	Resistor, fixed, 657 ohms, ±0.5%	Mepco	FE12C1
R907	Resistor, fixed, 328 ohms, ±0.5%	Mepco	FE12C1
R908	Resistor, fixed, 249 ohms, ±0.5%	Mepco	FE12C1
R909	Resistor, fixed, 24 k, 1/4 w, ±5%	-	RC07GF243J
R910	Resistor, fixed, 324 ohms, ±1%	Mepco	FE12C1
R911	Resistor, fixed, 12 k, 1/4 w, ±5%	-	RC07GF123J
R912	Resistor, fixed, 20 ohms, ±0.5%	Mepco	FE12C1
R913	Resistor, fixed, 18.4 ohms, ±0.5%	Mepco	FE12C1
R914	Resistor, fixed, 10 ohms, 1%	-	RN20X10R0F
R915	Resistor, fixed, 1.1 k, 1%	-	RN60C1101F
R916	Potentiometer, 200 ohms	Allen-Bradley	JA1L0405201VC
R917, R919	Resistor, fixed, 2 k, 1/4 w, ±5%	-	RC07GF202J
R918	Resistor, fixed, 510 ohms, 1/4 w, ±5%	-	RC07GF511J
R920, R922, R923	Resistor, fixed, 3.3 k, 1/4 w, ±5%	-	RC07GF332J
R921	Resistor, fixed, 2.2 k, 1/4 w, ±5%	-	RC07GF222J
R924	Resistor, fixed, 10 k, 1/4 w, ±5%	-	RC07GF103J
S901	Switch, pushbutton	AIL	213294
S902	Switch, rotary	AIL	213349
S903	Switch, toggle	Cutler-Hammer	CH8Z80K16
S904	Switch, pushbutton	AIL	211824
T901	Transformer	AIL	212243
	IF-AMPLIFIER-DETECTOR (P/N 212875)		
C101-C108	Capacitor, fixed, 1000 pF	-	CK05CW102K
C110-C117, C119-C121	Capacitor, fixed, 1000 pF	-	CK05CW102K

Item	Name	Manufacturer	Part No.
C123-C128, C131-C134	Capacitor, fixed, 1000 pF	-	CK05CW102K
C136, C142-C144	Capacitor, fixed, 1000 pF	-	CK05CW102K
C109	Capacitor, fixed, 15 pF	-	CK05CW150K
C118	Capacitor, fixed, 120 pF	-	CK05CW121K
C122	Capacitor, fixed, 0.22 μ F	Goodall	601PE
C129, C135	Capacitor, electrolytic, 15 μ F, 25 v	Spargue	TE1205
C130	Capacitor, electrolytic, 50 μ F, 6 v	Sprague	TE1100
C137-C141	Capacitor, feedthru, 1000 pF	Allen-Bradley	FB2B
CR101-CR105	Diode	Hewlett-Packard	HPA3039
J1, J2	Connector, BNC	-	UG1094/U
L101	Inductor, variable	AIL	212650-3
L102, L104, L106, L108, L112, L113	Inductor, fixed, 1.1 μ H	Jeffers	10101-1
L103, L105 L107, L111	Inductor, fixed, 14 μ H	Jeffers	10102-1
L109	Inductor, fixed, 0.47 μ H	Jeffers	4411-4M
L110	Inductor, fixed, 3 μ H	Jeffers	10100-2
R101	Resistor, fixed, 51 ohms, 1/4 w, ±5%	-	RC07GF510J
R102, R108	Resistor, fixed, 820 ohms, 1/4 w, ±5%	-	RC07GF821J
R103, R109	Resistor, fixed, 1.6 k, 1/4 w, ±5%	-	RC07GF162J
R104	Resistor, fixed, 33 ohms, 1/4 w, ±5%	-	RC07GF330J
R105	Resistor, fixed, 100 ohms, 1/4 w, ±5%	-	RC07GF101J
R106	Resistor, fixed, 360 ohms, 1/4 w, ±5%	-	RC07GF361J
R107, R113 R118	Resistor, fixed, 300 ohms, 1/4 w, ±5%	-	RC07GF301J
R110	Resistor, fixed, 15 ohms, 1/4 w, ±5%	-	RC07GF150J
R111, R127, R128, R132	Resistor, fixed, 200 ohms, 1/4 w, ±5%	-	RC07GF201J
R112	Resistor, fixed, 430 ohms, 1/4 w, ±5%	-	RC07GF431J
R114	Resistor, fixed, 6.2 k, 1/4 w, ±5%	-	RC07GF622J
R115, R134	Resistor, fixed, 3.9 k, 1/4 w, ±5%	-	RC07GF392J

Item	Name	Manufacturer	Part No.
R116	Resistor, fixed, 20 ohms, 1/4 w, ±5%	-	RC07GF200J
R117	Resistor, fixed, 680 ohms, 1/4 w, ±5%	-	RC07GF681J
R119	Resistor, fixed, 390 ohms, 1/4 w, ±5%	-	RC07GF391J
R120	Resistor, fixed, 3 k, 1/4 w, ±5%	-	RC07GF302J
R121	Resistor, fixed, 2 k, 1/4 w, ±5%	-	RC07GF202J
R122	Resistor, fixed, 620 ohms, 1/4 w, ±5%	-	RC07GF621J
R123	Resistor, fixed, 120 ohms, 2 w, ±5%	-	RC42GF121J
R124	Resistor, fixed, 47 ohms, 2 w, ±5%	-	RC07GF470J
R125, R129	Resistor, fixed, 2.2 k, ±5%	-	RC07GF222J
R126	Resistor, fixed, 75 ohms, ±5%	-	RC07GF251J
R130	Resistor, fixed, 2.4 k, ±5%	-	RC07GF242J
R131, R133	Resistor, fixed, 330 ohms, ±5%	-	RC07GF331J
R135	Resistor, fixed, 1.3 k, ±5%	-	RC07GF132J
R136	Resistor, fixed, 22.1 k, 1/4 w, 1%	-	RN65C2212F
R137	Resistor, fixed, 5.1 k, 1/4 w, ±5%	-	RC07GF512J
R138	Resistor, fixed, 1.5 k, 1/4 w, ±5%	-	RC07GF152J
T101-T103	Transformer	AIL	212567-2
T104	Transformer	AIL	212567-1
Q101, Q102	Transistor	-	2N4125
Q103, Q104	Transistor	-	2N2996
Q105-Q108	Transistor	-	2N4123
	AGC IF AMPLIFIER (P/N 212881)		
C201, C202, C203, C205, C206, C207	Capacitor, fixed, 0.01 μ F	Goodall	601PE
C204	Capacitor, fixed, 39 pF	-	CK05CW390K
C208	Capacitor, fixed, 0.22 μ F	Goodall	601PE
C209-C216, C218-C221, C223, C224	Capacitor, fixed, 1000 pF	-	CR05CW102K
C217	Capacitor, electrolytic, 50 μ F, 6 v	Spargue	TE1100
C222	Capacitor, electrolytic, 15 μ F, 25 v	Sprague	TE1205
C225-C228	Capacitor, feedthru, 1000 pF	Allen-Bradley	FB2B

Item	Name	Manufacturer	Part No.
CR201, CR202	Diode	Hewlett-Packard	HPA3039
L201	Inductor, fixed, 3 μ H	Jeffers	10100-2
L202, L204-L206	Inductor, fixed, 1.1 μ H	Jeffers	10101-1
L203	Inductor, fixed, 14 μ H	Jeffers	10102-1
P2	Plug, BNC	-	UG88A/U
R201	Resistor, fixed, 51 ohms, 1/4 w, ±5%	-	RC07GF510J
Q201, Q203	Transistor	-	2N2996
Q202	Transistor	-	2N708
Q204-Q207	Transistor	-	2N4123
R201	Resistor, fixed, 51 ohms, 1/4 w, ±5%	-	RC07GF510J
R202	Resistor, fixed, 4.7 k, 1/4 w, ±5%	-	RC07GF472J
R203	Resistor, fixed, 6.8 k, 1/4 w, ±5%	-	RC07GF682J
R204, R218, R220	Resistor, fixed, 330 ohms, 1/4 w, ±5%	-	RC07GF331J
R205	Resistor, fixed, 1 k, 1/4 w, ±5%	-	RC07GF102J
R206	Resistor, fixed, 100 ohms, 1/4 w, ±5%	-	RC07GF101J
R207	Resistor, fixed, 100 ohms, 1/8 w, ±1%	-	RH60C1000F
R208	Resistor, fixed, 1.8 k, 1/4 w, ±5%	-	RC07GF182J
R210	Resistor, fixed, 910 ohms, 1/4 w, ±1%	-	RH65C9100F
R211	Resistor, fixed, 2 k, 1/4 w, ±5%	-	RC07GF202J
R212	Resistor, fixed, 43 ohms, 1/4 w, ±5%	-	RC07GF430J
R213	Resistor, fixed, 82 ohms, 1/4 w, ±5%	-	RC07GF820J
R214, R216, R221	Resistor, fixed, 200 ohms, 1/4 w, ±5%	-	RC07GF201J
R215	Resistor, fixed, 2.2 k, 1/4 w, ±5%	-	RC07GF222J
R217	Resistor, fixed, 2.4 k, 1/4 w, ±5%	-	RC07GF242J
R219	Resistor, fixed, 3.9 k, 1/4 w, ±5%	-	RC07GF392J
R222	Resistor, fixed, 22.1 k, 1/4 w, ±1%	-	RN65C2212F
R223	Resistor, fixed, 5.1 k, 1/4 w, ±5%	-	RC07GF512J
R224	Resistor, fixed, 1.5 k, 1/4 w, ±5%	-	RC07GF152J
	AGC AMPLIFIER (P/N 212935)		
C501, C503, C507, C510	Capacitor, fixed, 1000 pF	-	CK05CW102K

Item	Name	Manufacturer	Part No.
C502, C504, C505, C508, C509	Capacitor, fixed, 100 μ F, 25 v	Sprague	TE1211
C506	Capacitor, electrolytic, 2.2 μ F, 6 v	-	CS13BE225
C511	Capacitor, fixed, 270 pF	Elmenco	DM10F271J
CR501, CR502, CR504, CR505	Diode	-	1N2071
CR503	Diode	-	1N936
L501	Conductor, fixed, 1.1 μ H	Jeffers	10101-1
Q501, Q505	Transistor	-	2N4125
Q502, Q503, Q504, Q509	Transistor	-	2N4123
Q506, Q507	Transistor	-	2N4124
Q508	Transistor	Siliconix Inc.	U149
R501	Resistor, fixed, 75 ohms, 1 w, ±5%	-	RC32GF750J
R502	Resistor, fixed, 270 k, 1/4 w, ±5%	-	RC07GF271J
R503, R505	Resistor, fixed, 5.6 k, 1/4 w, ±5%	-	RC07GF562J
R504	Resistor, fixed, 6.8 k, 1/4 w, ±5%	-	RC07GF682J
R506	Resistor, fixed, 3.9 k, 1/4 w, ±5%	-	RC07GF392J
R507	Resistor, fixed, 22 k, 1/4 w, ±5%	-	RC07GF223J
R508	Resistor, fixed, 82 k, 1/4 w, ±5%	-	RC07GF823J
R509	Resistor, fixed, 1.2 k, 1 w	Dale	CW1A
R510	Resistor, fixed, 39 k, 1/4 w, ±5%	-	RC07GF393J
R511	Resistor, fixed, 8.2 k, 1 w	Dale	CW1A
R512	Resistor, fixed, 1.8 k, 1/4 w, ±5%	-	RC07GF182J
R513	Resistor, fixed, 100 ohms, 3 w	Sprague	243E1015
R514	Resistor, fixed, 1 k, 1/4 w, ±5%	-	RC07GF102J
R515, R516	Resistor, fixed, 47 k, 1/4 w, ±5%	-	RC07GF473J
R517	Resistor, fixed, 56 k, 1/4 w, ±5%	-	RC07GF563J
R18	Resistor, fixed, 4.3 k, 1/4 w, ±5%	-	RC07GF432J
R519	Resistor, fixed, 8.2 k, 1/4 w, ±5%	-	RC07GF822J
R520	Resistor, fixed, 5.1 k, 1/4 w, ±5%	-	RC07GF512J
R521	Resistor, fixed, 2.2 Mego, 1/4 w, ±5%	-	RC07GF225J

Item	Name	Manufacturer	PART NO.
R522	Resistor, fixed, 2.2 k, 1/2 w, ±5%		RC20GF222J
	VIDEO AMPLIFIER-SYNCHRONOUS DETECTOR (P/N 212920)		
C303	Capacitor, fixed, 0.047 μ F	Goodall	601PE
C305	Capacitor, fixed, 0.005 μ F	Erie	811-005
C306	Capacitor, fixed, 0.01 μ F	Goodall	601PE
C307	Capacitor, fixed, 2200 pF	-	CK066W222K
C309, C310	Capacitor, electrolytic, 100 μ F, 25 v	Sprague	TE1211
C311	Capacitor, electrolytic, 1 μ F, 50 v	Hopkins	1PP5D
CR301-CR304	Diode	-	1N625
CR305	Diode	-	1N4740
Q301, Q304, Q306	Transistor	-	2N4123
Q302	Transistor	-	2N929
Q303, Q305, Q307	Transistor	-	2N4125
R302	Resistor, fixed, 100 k, 1/4 w, ±5%	-	RC07GF104J
R303	Resistor, fixed, 820 k, 1/4 w, ±5%	-	RC07GF824J
R304	Resistor, fixed, 220 k, 1/4 w, ±5%	-	RC07GF224J
R305	Resistor, fixed, 24 k, 1/4 w, ±5%	-	RC07GF243J
R306	Resistor, fixed, 10 k, 1/4 w, ±1%	-	RN20X1002F
R308	Resistor, fixed, 23.7 k, 1/4 w, ±1%	-	RN65C2372F
R309	Resistor, fixed, 5.6 k, 1/4 w, ±5%	-	RC07GF562J
R311	Resistor, fixed, 4.7 k, 1/4 w, ±5%	-	RC07GF472J
R312, R316	Resistor, fixed, 1 k, 1/4 w, ±5%	-	RC07GF102J
R313	Resistor, fixed, 560 ohms, 1/4 w, ±5%	-	RC07GF561J
R314	Resistor, fixed, 22 k, 1/4 w, ±5%	-	RC07GF223J
R315	Resistor, fixed, 200 k, 1/4 w, ±5%	-	RC07GF204J
R317	Resistor, fixed, 47 k, 1/4 w, ±5%	-	RC07GF473J
R318, R319	Resistor, fixed, 5.11 k, 1/4 w, ±5%	Mepco	FFE12
R320-R323	Resistor, fixed, 2.2 k, 1/4 w, ±5%	-	RC07GF222J
T301	Transformer	UTC	SS0-8F

Item	Name	Manufacturer	Part No.
	MULTIVIBRATOR (P/N 212925)		
C601, C605	Capacitor, fixed, 1000 pF	-	CK05CW102K
C602, C607, C608	Capacitor, fixed, 0.033 μ F	Goodall	601PE
C603, C609	Capacitor, fixed, 0.01 μ F	Goodall	601PE
C604, C606	Capacitor, electrolytic, 100 μ F, 25 v	Sprague	TE1211
C610	Capacitor, fixed, 0.01 μ F	-	CK63AW103M
CR601, CR602	Diode	-	1N2071
Q601, Q602	Transistor	-	2N4125
Q603-Q607	Transistor	-	2N4123
R601	Resistor, fixed, 16 k, 1/4 w, ±5%	-	RC07GF163J
R602, R603	Resistor, fixed, 3.9 k, 1/4 w, ±5%	-	RC07GF392J
R604	Resistor, fixed, 910 ohms, 1/4 w, ±5%	-	RC07GF911J
R605	Resistor, fixed, 3 k, 1/4 w, ±5%	-	RC07GF302J
R606, R613, R619	Resistor, fixed, 5.6 k, 1/4 w, ±5%	-	RC07GF562J
R607	Resistor, fixed, 27 k, 1/4 w, ±5%	-	RC07GF273J
R608, R610	Resistor, fixed, 180 ohms, 1 w, ±5%	-	RC32GF181J
R609, R621	Resistor, fixed, 12 k, 1/4 w, ±5%	-	RC07GF123J
R611, R620	Resistor, fixed, 390 ohms, 1 w, ±5%	-	RC32GF391J
R612, R615 R616, R618	Resistor, fixed, 4.7 k, 1/4 w, ±5%	-	RC07GF472J
R614, R617	Resistor, fixed, 56 k, 1/4 w, ±5%	-	RC07GF563J
	GAS NOISE GENERATOR POWER SUPPLY (P/N 213277)		
C801	Capacitor, electrolytic, 15 μ F, 25 v	Sprague	TE1205
CR801-CR805	Diode	-	1N2071
Q801, Q804	Transmitter	-	2N4123
Q802, Q803	Transistor	-	DTS401
R801	Resistor, fixed, 47 k, 4 w	Malloy	4MOL
R802	Resistor, fixed, 510 ohms, 2 w, ±5%	-	RC42GF511J
R803	Resistor, fixed, 3.9 k, 1/4 w, ±5%	-	RC07GF392J
R804, R805	Resistor, fixed, 51 ohms, 1/4 w, ±5%	-	RC07GF510J
R806	Resistor, fixed, 10.5 k, 1/4 w, ±1%	-	RN65C1052F

Item	Name	Manufacturer	Part No.
R807	Resistor, fixed, 4 ohms, 1 w	Dale	RS1A
R808, R810	Resistor, fixed, 20 ohms, 1/2 w, ±5%	-	RC20GF200J
R809	Resistor, fixed, 2.2 k, 1/4 w, ±5%	-	RC07GF222J
	IGNITION MODULE (P/N 213000)		
C701	Capacitor, electrolytic, 21,000 μ F	Sprague	36D213G015 BB2A
C702	Capacitor, electrolytic, 15 μ F, 25 v	Sprague	TE1205
CR701, CR702	Diode	-	1N3208
CR703, CR704	Diode	Electronic Devices	ED8523
Q701, Q702	Transistor	-	2N4123
Q703	Transistor	-	2N3054
Q704	Transistor	-	2N3055
R701, R705	Resistor, fixed, 3.3 k, 1/4 w, ±5%	-	RC07GF332J
R702, R706	Resistor, fixed, 5.6 k, 1/4 w, ±5%	-	RC07GF562J
R703	Resistor, fixed, 1 k, 1/4 w, ±5%	-	RC07GF102J
R704	Resistor, fixed, 680 ohms, 1/4 w, ±5%	-	RC07GF681J
R707	Resistor, fixed, 330 ohms, 1/4 w, ±5%	-	RC07GF331J
R708	Resistor, fixed, 15 ohms, 1 w, ±5%	-	RC32GF150J
R709	Resistor, fixed, 100 ohms, 1/4 w, ±5%	-	RC07GF101J
R710	Resistor, fixed, 4 ohms, 10 w, ±20%	-	RC07GF10XM
T701	Transformer	AIL	213038
T702	Transformer	AIL	212479
PS901	POWER SUPPLY (P/N 212967) (POWER MATE P/N P667)		
C1	Capacitor, electrolytic, 1300 μ F, 50 v	General Inst	G100 SERIES
C2, C3	Capacitor, electrolytic, 10 μ F, 150 v	General Inst	G100 SERIES
C4	Capacitor, electrolytic, 0.047 μ F, 100 v	General Inst	G100 SERIES
C5	Capacitor, electrolytic, 0.64 μ F, 64 v	General Inst	G100 SERIES
C6	Capacitor, electrolytic, 50 μ F, 50 v	General Inst	G100 SERIES
CR1-CR6	Diode	Solitron	CER68
CR7	Diode	-	1N753

Item	Name	Manufacturer	Part No.
CR8	Diode	-	1N751
Q1	Transistor	-	2N3569
Q2-Q5	Transistor	-	2N3394
Q6	Transistor	-	2N3055
R1	Resistor, Carbon, 12 k, 1/2 w, ±5%	-	COML
R2	Resistor, Carbon, 5.6 k, 1/2 w, ±5%	-	COML
R3	Resistor, Carbon, 180 ohms, 1/2 w, ±5%	-	COML
R4	Resistor, Carbon, 2 ohms, 3 w, ±5%	-	COML
R5	Resistor, Carbon, 1 k, 1/2 w, ±5%	-	COML
R6	Resistor, Carbon, 2.7 k, 1/2 w, ±5%	-	COML
R7	Resistor, Carbon, 2.2 k, 1/2 w, ±5%	-	COML
R8	Resistor, Carbon, 6.8 Mego, 1/2 w, ±5%	-	COML
R9	Resistor, Carbon, 820 ohms, 1/2 w, ±5%	-	COML
R10	Resistor, Variable, 5 k	-	COML
R11	Resistor, Carbon, 7.5 k, 1/2 w, ±5%	-	COML
R12	Resistor, Carbon, 3.3 k, 1/2 w, ±5%	-	COML
R13	Resistor, Carbon, 1.2 k, 1/2 w, ±5%	-	COML
R14	Resistor, Carbon, 18 k, 1/2 w, ±5%	-	COML
R15	Resistor, Carbon, 1.8 k, 1/2 w, ±5%	-	COML
R17	Resistor, Carbon, 33 k, 1/2 w, ±5%	-	COML
T1	Transformer	PMC	T85X.29/1.2-29/1.2
PS901	POWER SUPPLY (P/N 212967) (TODD P/N 3XS1445)		
C1	Capacitor, 160 mF, 25V, +150%,-10%, al electrolytic	-	COML
C2, C7	Capacitor, 5000 pF, 1000V, ±20%, ceramic	-	COML
C3	Capacitor, .047 mF, 250V, ±20%, mylar	-	COML
C8	Capacitor, .047 mF, 250V, ±20%, mylar	-	COML
C9	Capacitor, 10 mF, 20V, +150%, -10%, tantalum	-	COML
C10	Capacitor, .022 mF, 250V, ±20%, mylar	-	COML
C101	Capacitor, 1150 mF, 50V, +150%, -10%, al electrolytic	-	COML
C105	Capacitor, 100 mF, 40V, +150%, -10%, al electrolytic	-	COML

Item	Name	Manufacturer	Part No.
C106, C107	Capacitor, .033 mF, 400V, ±20%, mylar	-	COML
CR1, CR2, CR5, CR6, CR8, CR13, CR14	Diode	-	1N4004
CR3	Diode, Zener, 1.5	Power Components	JZ15B
CR9, CR10, CR11, CR12	Diode	-	1N4004
CR108	Diode	-	1N4004
A1	Integrated Circuit	Fairchild	U5R7723312
R16	Potentiometer, 1KΩ, 1.5 watt	CTS	Type 110
R111	Potentiometer, 1.5KΩ, 5 watt, crmet	Bournes	Type 30800
R1	Resistor, fixed, 330Ω, 0.5W, ±10%	-	RC20GF331K
R3	Resistor, fixed, 470Ω, 0.5W, ±10%	-	RC20GF471K
R4, R23	Resistor, fixed, 1.5KΩ, 0.5W, ±10%	-	RC20GF152K
R5, R6, R8, R9	Resistor, film, 2.95KΩ, 0.5W, ±10%	-	RN70B2951F
R10	Resistor, film, 20.5KΩ, 0.5W, ±1%	-	RN70B2052F
R11	Resistor, fixed, 1.2KΩ, 0.5W, ±10%	-	RC20GF122K
R12	Resistor, fixed, 10KΩ, 0.5W, ±10%	-	RC20GF103K
R13	Resistor, fixed, 100KΩ, 0.5W, ±10%	-	RC20GF104K
R17	Resistor, film, 5.62KΩ, 0.5W, ±1%	-	RN70B5621F
R20	Resistor, fixed, 220Ω, 0.5W, ±10%	-	RC20GF221K
R21, R22	Resistor, fixed, 1KΩ, 0.5W, ±10%	-	RC20GF102K
R101	Resistor, wire-wound, 0.82Ω, 2W, ±10% B WH	-	COML
R112	Resistor, fixed, 100Ω, 0.5W, ±10%	-	RC20G101K
T101	Transformer	Todd	1050024
Q1	Transistor	-	2N3638A
Q3	Transistor	-	2N3566
Q101	Transistor	Todd	4223055

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